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GROUND-BASED PROPAGATION MEASUREMENTS IN SUPPORT OF FLIGHT EVAL--ETC(U)
FEB 79 P A KOSSEY, J E RASMUSSEN, J P TURTLE

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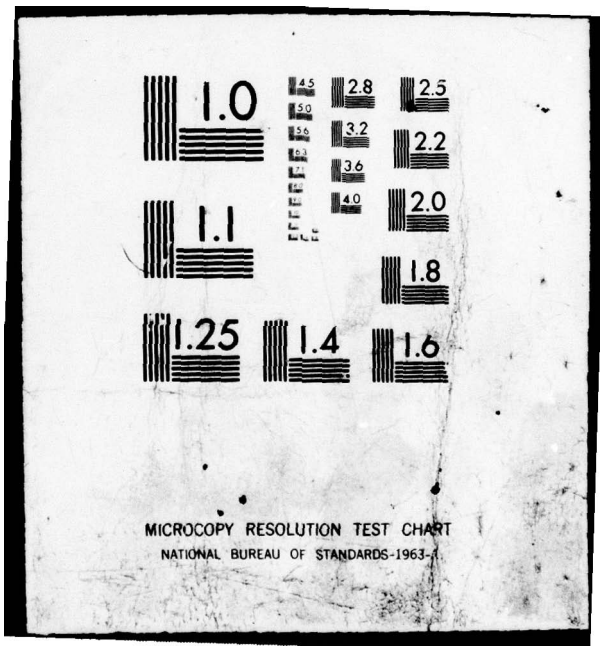
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GROUND-BASED PROPAGATION MEASUREMENTS IN SUPPORT OF FLIGHT EVALUATION OF THE E-3A OMEGA NAVIGATION SYSTEM, JUNE - NOVEMBER 1976

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ROME AIR DEVELOPMENT CENTER
Air Force Systems Command
Griffiss Air Force Base, New York 13441

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A summary is provided of ground-based propagation measurements made in conjunction with flight tests of the Air Force's E-3A aircraft OMEGA navigation system. Atmospheric noise data at 10.6 kHz and the signal strengths and time differences of OMEGA transmissions from Hawaii, Japan, and North Dakota are described, as recorded at Vandenberg AFB, California, and Almira, Washington, during the period of June—November 1976.

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Preface

The measurements described in this report were obtained at the request of the ESD 411L System Program Office, Hanscom AFB, Massachusetts, which provided funds to support the effort in part. The need for such data was brought to the authors' attention by Lt. Mark Tigerman, whose generous support throughout the period of the program is gratefully acknowledged. Appreciation is also extended to Airman William Johnson of the Propagation Branch of RADC for his efforts during the data-taking phase of the program at Almira, Washington. The authors wish to especially acknowledge the efforts of Mr. Royce C. Kahler of Barkley and Dexter Laboratories, Fitchburg, Massachusetts, in the development of the receiving system used throughout the measurements program, and Mr. Wayne I. Klemetti of Megapulse Corporation, Bedford, Massachusetts, for his aid in the data reduction and graphics presentation aspects of this report.

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Ground-Based Propagation Measurements in Support of Flight Evaluation of the E-3A OMEGA Navigation System, June — November 1976

1. INTRODUCTION

During the period June—November 1976 the Propagation Branch of the Rome Air Development Center conducted a field program to provide support to the ESD 411-L System Program Office in evaluating the performance of the E-3A airborne long-range OMEGA navigation system. For this a ground-based very-low-frequency (VLF) receiving system was operated at Vandenberg AFB, California, and later, at Almira, Washington, to monitor OMEGA transmissions from Japan, Hawaii, and North Dakota. Both phase and amplitude information were recorded for comparison with similar data being observed on the E-3A aircraft, so that instrumental effects peculiar to the aircraft operations could be distinguished from wave propagation fluctuations and other natural phenomena.

This report provides a summary of the ground-based observations made during the E-3A flight test program. Signal strengths, time differences, and atmospheric noise data are given in the hope that they may be useful to those interested in the propagation characteristics of long radio waves, and to those particularly concerned with aspects of the OMEGA navigation system.

(Received for publication 27 February 1979)

2. THE GROUND-BASED OMEGA RECEIVING SYSTEM

Figure 1 shows the block-diagram representation of the receiving system used to monitor the OMEGA transmissions at Vandenberg AFB, California, and Almira, Washington. The system provided individual recordings of the amplitudes and phases of the 10.2 kHz and the 13.6 kHz transmissions from three OMEGA transmitters (Japan, Hawaii, and North Dakota). In addition, 10.6 kHz atmospheric noise data were recorded (in a 100 Hz bandwidth) so that signal-to-noise ratios could be estimated for each of the propagation paths being monitored. Calibrations were performed for all the paths so that time differences between station pairs could be quickly obtained and checked against expected nominal values at the receiving site. The station pairs monitored were: Hawaii-North Dakota (C-D), North Dakota-Japan (D-H), and Hawaii-Japan (C-H). Data were obtained at Vandenberg AFB, California, during E-3A flights in June and July 1976, and at Almira, Washington, for flights in August, September, and October 1976. A photograph of the receiving system is shown in Figure 2.

3. OMEGA PROPAGATION DATA—VANDENBERG AFB, CALIFORNIA

Data were obtained at Vandenberg AFB, California (34° 47' 45" N, 120° 35' 16" W) on 22, 23, 25 June and 13, 19, 20, 21, 22 July 1976.

3.1 Time Difference Measurements

Figures 3 to 14 give OMEGA time differences (in microseconds) for 10.2 kHz and 13.6 kHz, as recorded at Vandenberg AFB in June and July 1976. Also shown are the nominal time differences predicted for Vandenberg using the standard Defense Mapping Agency OMEGA Propagation Prediction Tables.* The agreements between the observed and predicted values were usually very good for all station pairs. Exceptions to this occurred, however, for station pairs North Dakota-Japan (D-H) and Hawaii-Japan (C-H) at times when the paths to Japan were in transition from day-to-night conditions, or vice versa. For those times the observations may provide information that can be used to adjust the OMEGA Propagation Tables and improve the predictions. During the period of the Vandenberg observations there were no discernible ionospheric disturbances; that is, the OMEGA propagation environment was very good.

*Published by the Defense Mapping Agency Hydrographic Center, Washington, D.C. 20390

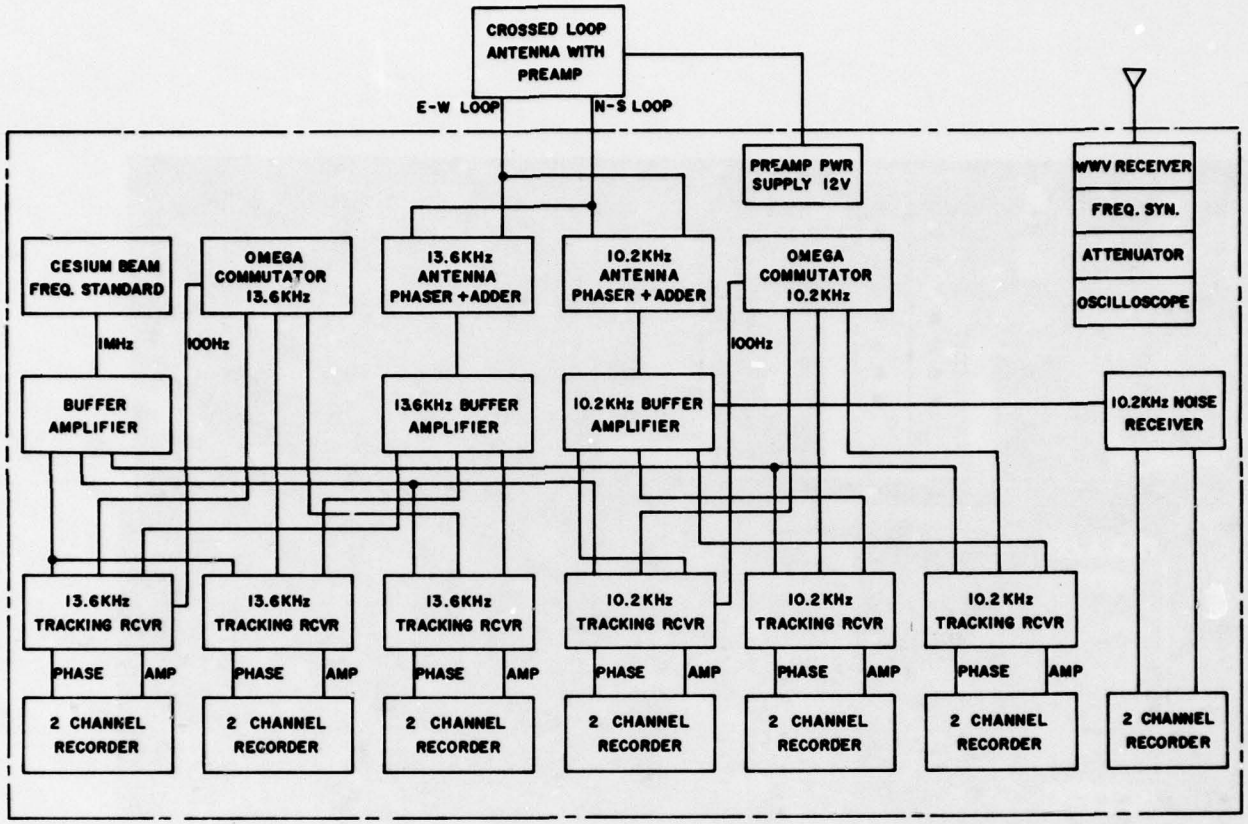

Figure 1. Block Diagram of the OMEGA Receiving System

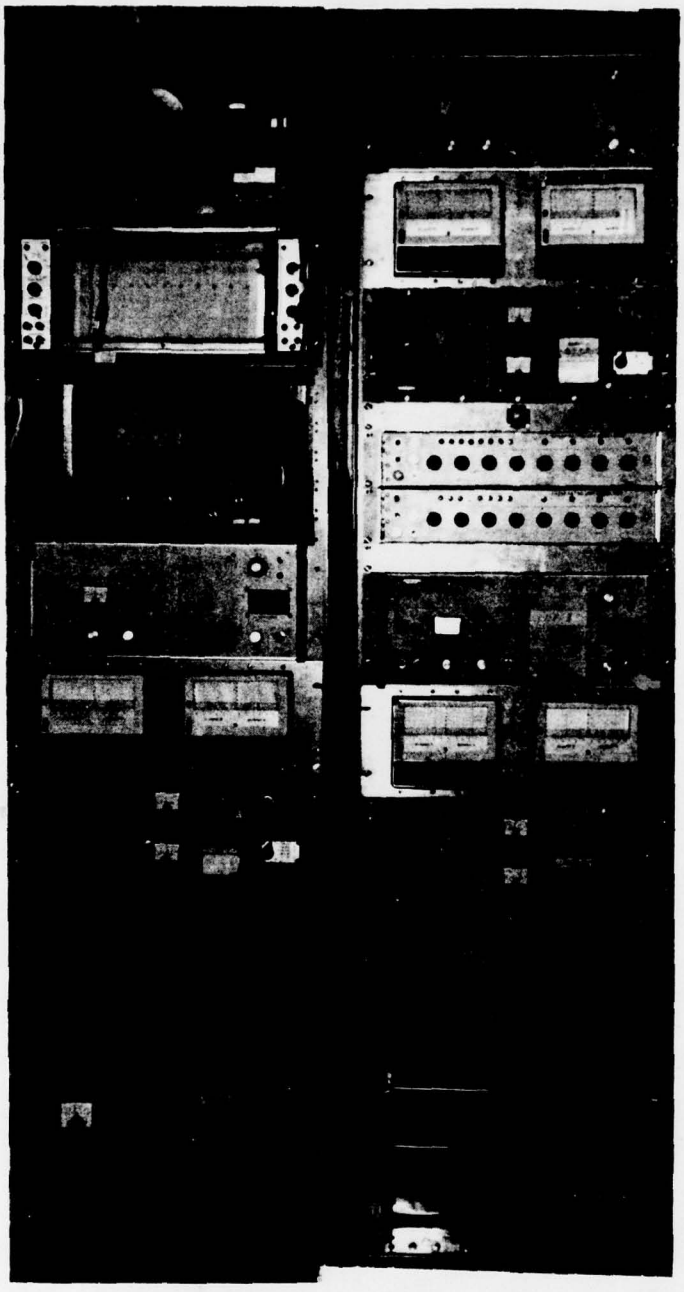

Figure 2. Photograph of the OMEGA Receiving System

3.2 Omega Signal Strengths and Noise Data

Tables 1 to 9 give OMEGA signal strengths and atmospheric noise as recorded at Vandenberg in June and July 1976. Since the noise data were recorded only at 10.6 kHz, the signal-to-noise ratios for 10.2 kHz and 13.6 kHz can only be estimated from the given data. Although the ground observations of the Omega transmissions from Japan were readable at all times, aircraft OMEGA systems could have experienced some difficulty with those transmissions, since the station operated only at quarter-power at times during the measurements program, and signal-to-noise ratios were often -15 dB to -20 dB, or worse.

4. OMEGA PROPAGATION DATA—ALMIRA, WASHINGTON

Propagation data, similar to that recorded at Vandenberg, were obtained at Almira, Washington (47° 46' 15" N, 118° 56' 00" W) in conjunction with E-3A flights during the months of August, September, and October 1976. Figures 15 to 44 give the observed time differences (in microseconds) for the Hawaii-North Dakota, North Dakota-Japan, and Hawaii-Japan station-pairs. Also shown are the predicted time differences derived from the appropriate Defense Mapping Agency Omega Propagation Prediction Tables. The agreements between the observed and predicted values were usually very good, except for station pairs that included Japan when the propagation paths to that country were in day-to-night (or night-to-day) transitions. In this regard the Almira data were consistent with that observed at Vandenberg. Throughout the period of the Almira observations, there were no significant ionospheric disturbances.

Tables 10 to 32 give Omega signal strengths and atmospheric noise data as recorded at Almira. At times the signal-to-noise ratios associated with the transmissions from Japan were -15 dB or worse, corresponding to times when that station was operating at greatly reduced power levels.

VANDENBERG AFB DATA

Figures 3-14
Tables 1-9

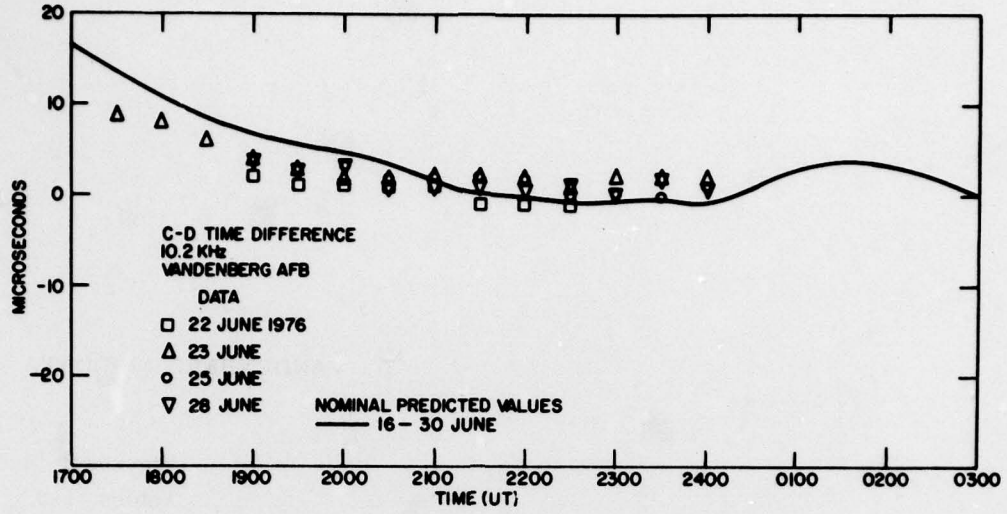

Figure 3. 10.2 kHz (C-D) Time Differences, Vandenberg, 16-30 June

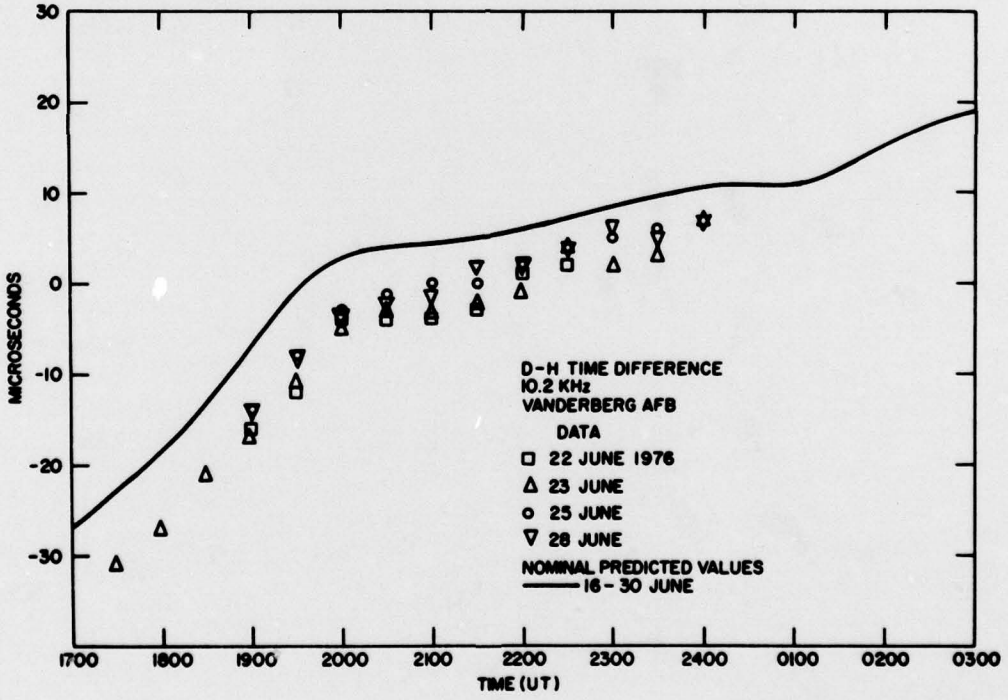

Figure 4. 10.2 kHz (D-H) Time Differences, Vandenberg, 16-30 June

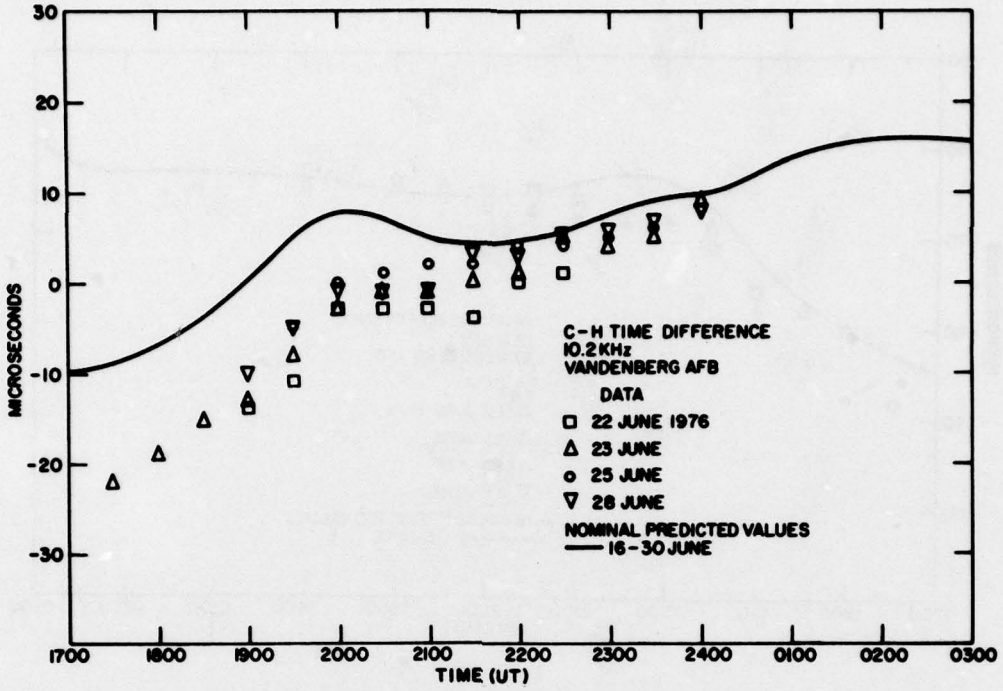

Figure 5. 10.2 kHz (C-H) Time Differences, Vandenberg, 16-30 June

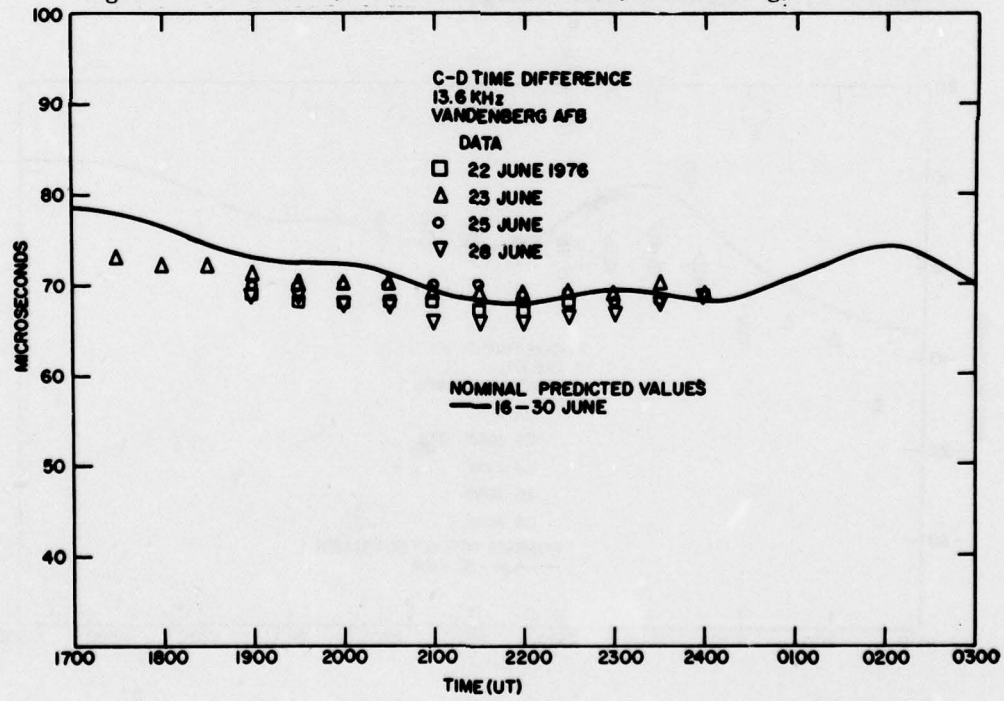

Figure 6. 13.6 kHz (C-D) Time Differences, Vandenberg, 16-30 June

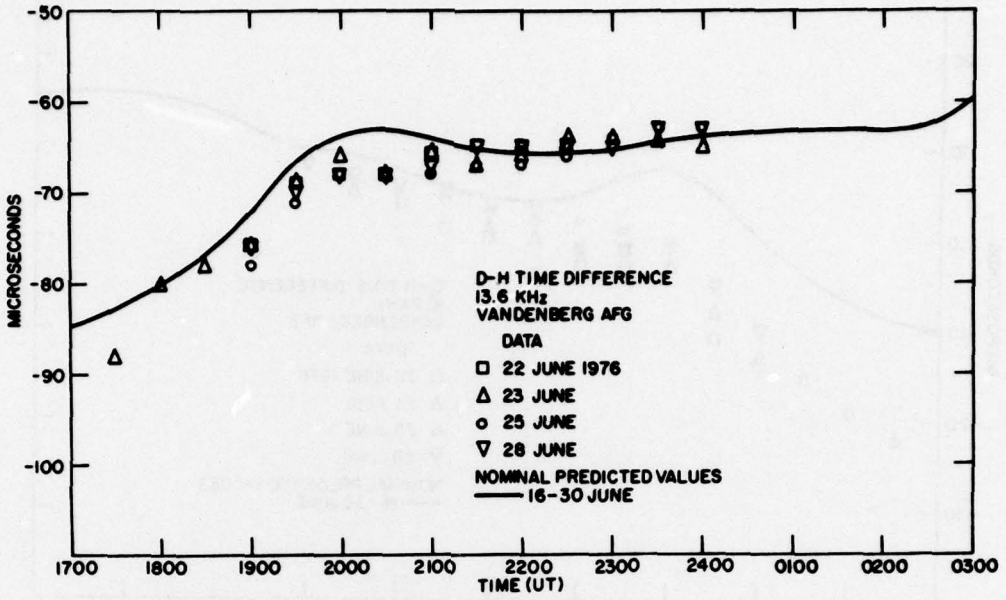

Figure 7. 13.6 kHz (D-H) Time Differences, Vandenberg, 16-30 June

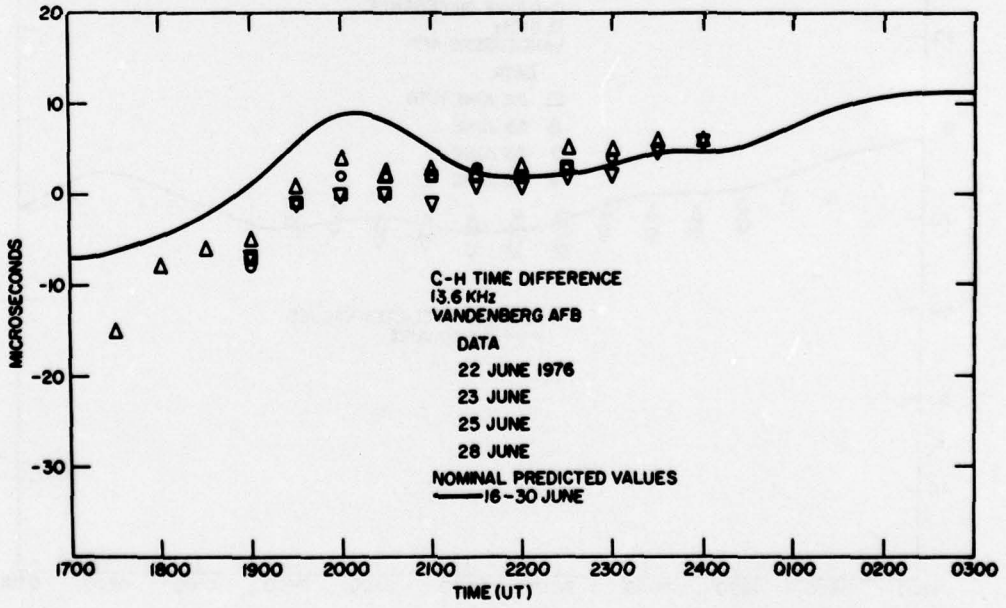

Figure 8. 13.6 kHz (C-H) Time Differences, Vandenberg, 16-30 June

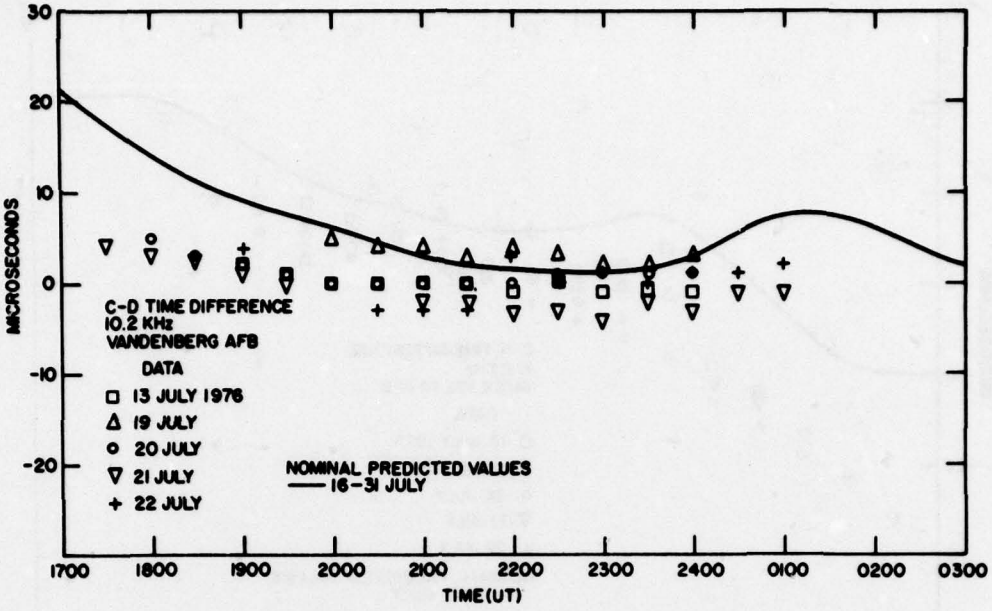

Figure 9. 10.2 kHz (C-D) Time Differences, Vandenberg, 13-31 July

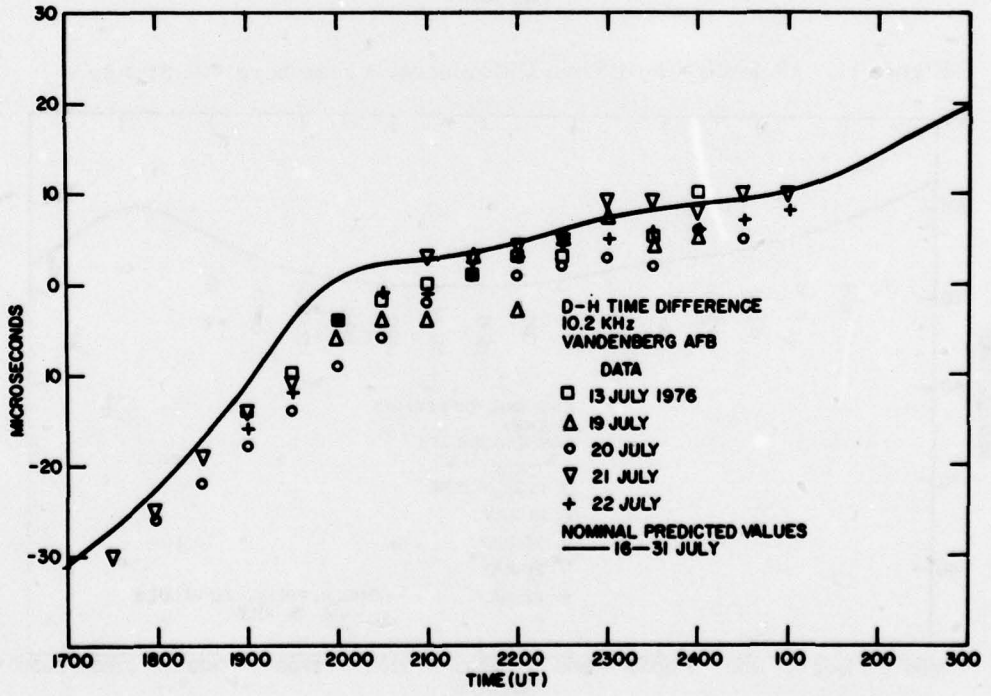

Figure 10. 10.2 kHz (D-H) Time Differences, Vandenberg, 13-31 July

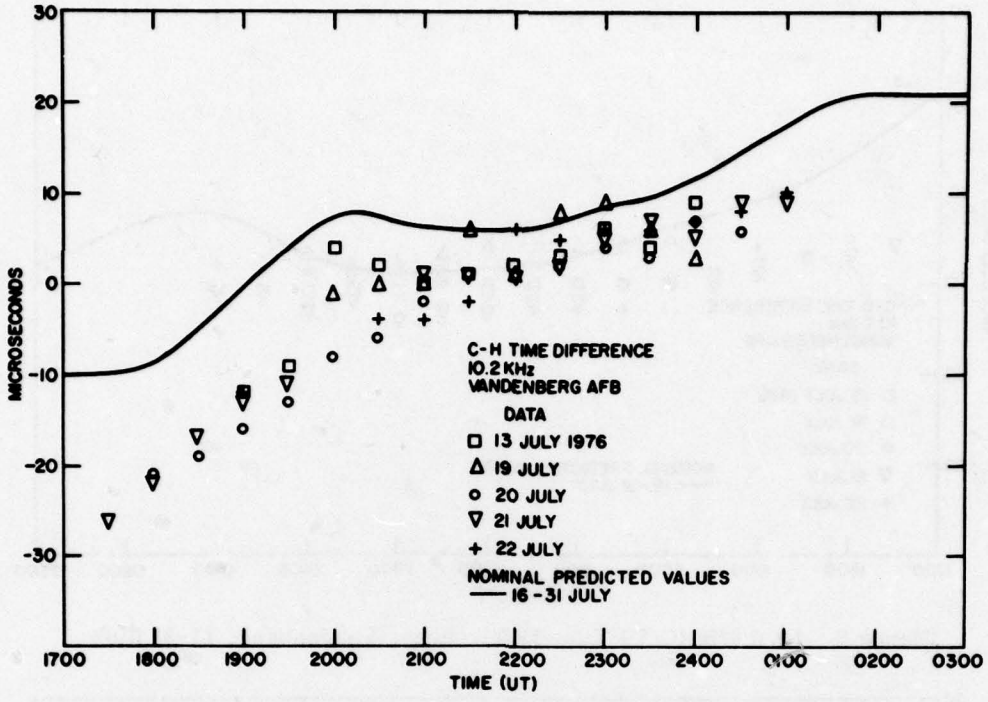

Figure 11. 10.2 kHz (C-H) Time Differences, Vandenberg, 13-31 July

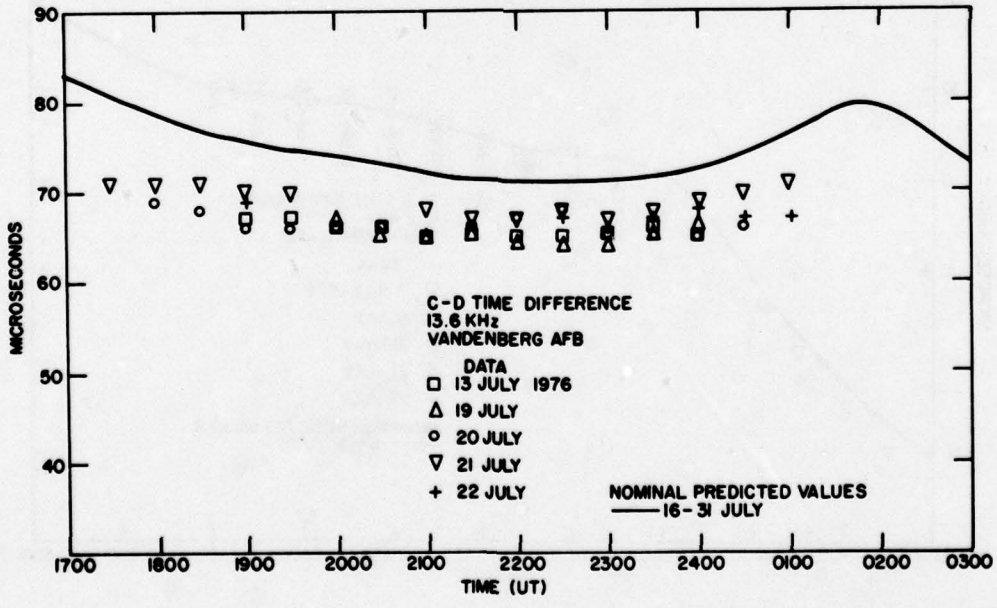

Figure 12. 13.6 kHz (C-D) Time Differences, Vandenberg, 13-31 July

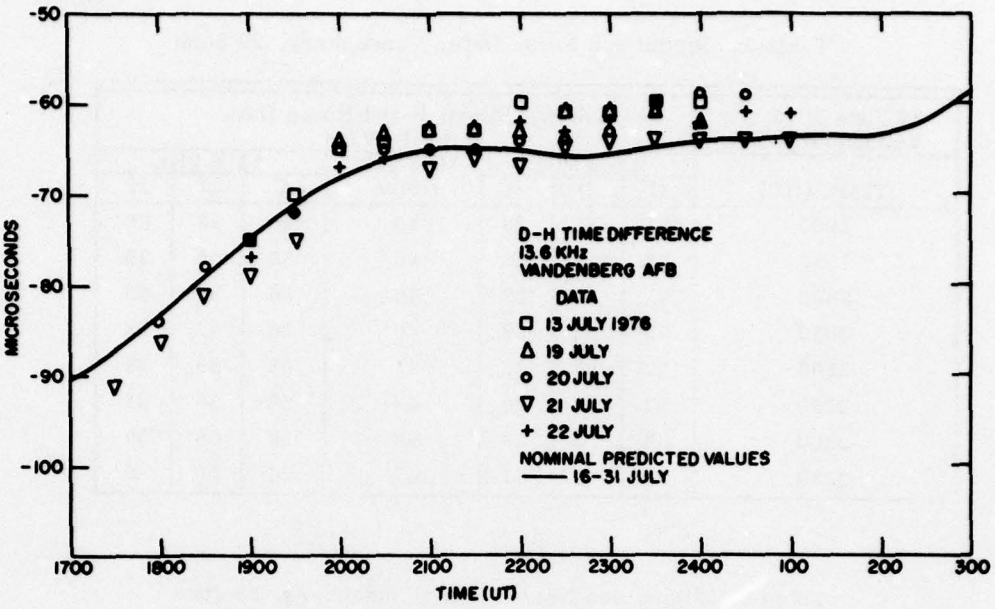

Figure 13. 13.6 kHz (D-H) Time Differences, Vandenberg, 13-31 July

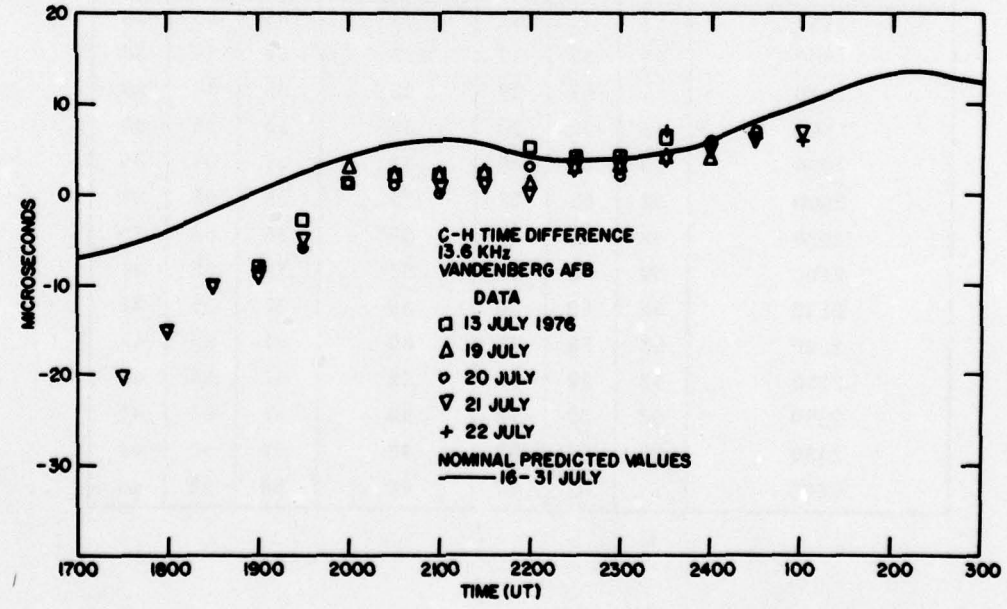

Figure 14. 13.6 kHz (C-H) Time Differences, Vandenberg, 13-31 July

Table 1. Signal and Noise Data, Vandenberg, 22 June

22 June 1976 Vandenberg AFB	Signal Strength and Noise Data dB > 1 μV/m						
	10.2 kHz			10.6 kHz	13.6 kHz		
TIME (UT)	C	D	H	Noise	C	D	H
1900	53	52	28	40	56	55	36
1930	53	52	25	40	56	55	35
2000	53	52	27	40	56	55	36
2030	53	52	28	40	56	55	36
2100	52	53	28	41	56	55	38
2130	52	52	28	43	56	55	37
2200	52	53	29	43	56	55	39
2230	52	52	31	42	56	55	39

Table 2. Signal and Noise Data, Vandenberg, 23 June

23 June 1976 Vandenberg AFB	Signal Strength and Noise Data dB > 1 μV/m						
	10.2 kHz			10.6 kHz	13.6 kHz		
TIME (UT)	C	D	H	Noise	C	D	H
1730	52	52	31	33	53	55	38
1800	53	52	30	33	54	55	36
1830	53	52	29	32	55	55	38
1900	53	52	29	33	55	55	36
1930	52	52	26	35	56	55	35
2000	52	52	27	35	56	55	37
2030	52	52	29	37	56	55	39
2100	52	52	29	37	56	55	41
2130	52	52	30	39	57	55	41
2200	53	52	31	40	57	55	43
2230	53	52	31	42	57	55	43
2300	53	52	32	42	57	55	44
2330	53	52	32	42	57	55	44
0000	53	52	37	40	58	55	46

Table 3. Signal and Noise Data, Vandenberg, 25 June

25 June 1976 Vandenberg AFB	Signal Strength and Noise Data dB > 1 μV/m						
	10.2 kHz			10.6 kHz	13.6 kHz		
TIME (UT)	C	D	H	Noise	C	D	H
1900	52	52	37	33	58	56	48
1930	53	52	35	33	58	55	46
2000	53	52	36	34	59	56	48
2030	53	52	37	36	59	55	48
2100	53	52	37	36	59	55	49
2130	53	52	37	36	59	55	49
2200	53	52	38	37	59	55	51
2230	53	52	38	39	59	55	51
2300	53	52	38	37	59	55	51
2330	53	52	38	39	58	55	51
0000	52	52	39	39	59	55	51

Table 4. Signal and Noise Data, Vandenberg, 28 June

28 June 1976 Vandenberg AFB	Signal Strength and Noise Data dB > 1 μV/m						
	10.2 kHz			10.6 kHz	13.6 kHz		
TIME (UT)	C	D	H	Noise	C	D	H
1900	53	52	36	37	58	55	48
1930	53	52	34	36	58	55	45
2000	53	53	36	37	58	55	46
2030	53	52	37	37	58	55	47
2100	53	53	37	39	58	55	47
2130	53	53	37	39	58	56	48
2200	53	52	36	40	58	56	48
2230	53	52	37	40	58	56	48
2300	53	52	37	40	58	55	48
2330	53	52	38	40	58	55	48
0000	53	53	38	40	58	55	49

Table 5. Signal and Noise Data, Vandenberg, 13 July

13 July 1976 Vandenberg AFB	Signal Strength and Noise Data dB > 1 μV/m						
	10.2 kHz			10.6 kHz	13.6 kHz		
TIME (UT)	C	D	H	Noise	C	D	H
1900	52	52	29	40	53	53	35
1930	53	52	27	41	53	53	35
2000	53	52	29	43	53	53	36
2030	53	52	28	45	54	53	36
2100	53	52	27	44	53	54	37
2130	52	52	30	44	53	54	38
2200	52	52	30	44	53	56	39
2230	52	52	30	44	53	56	39
2300	52	52	31	44	53	56	41
2330	52	52	29	44	53	57	40
0000	53	52	30	44	53	57	41

Table 6. Signal and Noise Data, Vandenberg, 19 July

19 July 1976 Vandenberg AFB	Signal Strength and Noise Data dB > 1 μV/m						
	10.2 kHz			10.6 kHz	13.6 kHz		
TIME (UT)	C	D	H	Noise	C	D	H
2000	53	52	27	42	54	55	35
2030	52	52	27	44	54	55	36
2100	52	52	28	44	53	55	38
2130	52	52	30	45	54	55	38
2200	52	52	27	46	54	55	38
2230	52	52	27	46	54	55	38
2300	52	52	29	47	54	55	39
2330	53	52	27	47	55	55	38
0000	53	52	31	47	55	55	39

Table 7. Signal and Noise Data, Vandenberg, 20 July

20 July 1976 Vandenberg AFB	Signal Strength and Noise Data dB > 1 μV/m						
	10.2 kHz			10.6 kHz	13.6 kHz		
TIME (UT)	C	D	H	Noise	C	D	H
1800	53	52	31	37	55	56	36
1830	53	52	30	40	55	56	37
1900	53	53	30	42	55	56	37
1930	53	53	27	44	55	56	34
2000	53	53	31	46	55	56	38
2030	53	53	27	46	55	56	38
2100	53	53	30	47	55	56	40
2130	53	53	30	47	55	56	39
2200	53	53	27	48	55	56	39
2230	53	53	29	48	55	56	40
2300	53	53	31	48	55	56	40
2330	53	53	30	48	55	56	40
0000	53	53	30	48	56	56	40
0030	53	52	32	48	55	56	40

Table 8. Signal and Noise Data, Vandenberg, 21 July

21 July 1976 Vandenberg AFB	Signal Strength and Noise Data dB > 1 μV/m						
	10.2 kHz			10.6 kHz	13.6 kHz		
TIME (UT)	C	D	H	Noise	C	D	H
1730	53	53	39	35	53	56	46
1800	53	52	39	37	53	56	42
1830	53	52	39	38	54	56	44
1900	53	52	38	42	55	56	44
1930	53	52	38	43	55	56	40
2000	--	--	--	--	--	--	--
2030	--	--	--	--	--	--	--
2100	53	52	38	48	55	56	45
2130	53	53	36	48	55	56	44
2200	53	53	39	48	55	56	45
2230	53	53	39	48	55	56	44
2300	53	53	38	46	55	56	46
2330	53	53	41	45	56	56	46
0000	53	53	39	44	56	56	46
0030	53	53	41	44	56	56	46
0100	53	52	39	42	56	56	46

Table 9. Signal and Noise Data, Vandenberg, 22 July

22 July 1976 Vandenberg AFB	Signal Strength and Noise Data db > 1 uV/m						
	10.2 kHz			10.6 kHz	13.6 kHz		
TIME (UT)	C	D	H	Noise	C	D	H
1900	53	53	36	40	54	56	44
1930	--	53	36	43	--	56	41
2000	--	53	38	43	--	56	43
2030	--	53	36	45	--	56	42
2100	--	52	37	44	--	56	44
2130	--	53	38	46	--	56	44
2200	--	53	38	46	--	56	44
2230	53	53	39	46	55	56	46
2300	53	53	39	46	56	56	46
2330	54	53	39	46	56	56	46
0000	54	53	40	45	56	56	46
0030	53	53	40	45	56	56	46
0100	54	52	42	45	56	56	46

ALMIRA, WASHINGTON DATA

Figures 15-44
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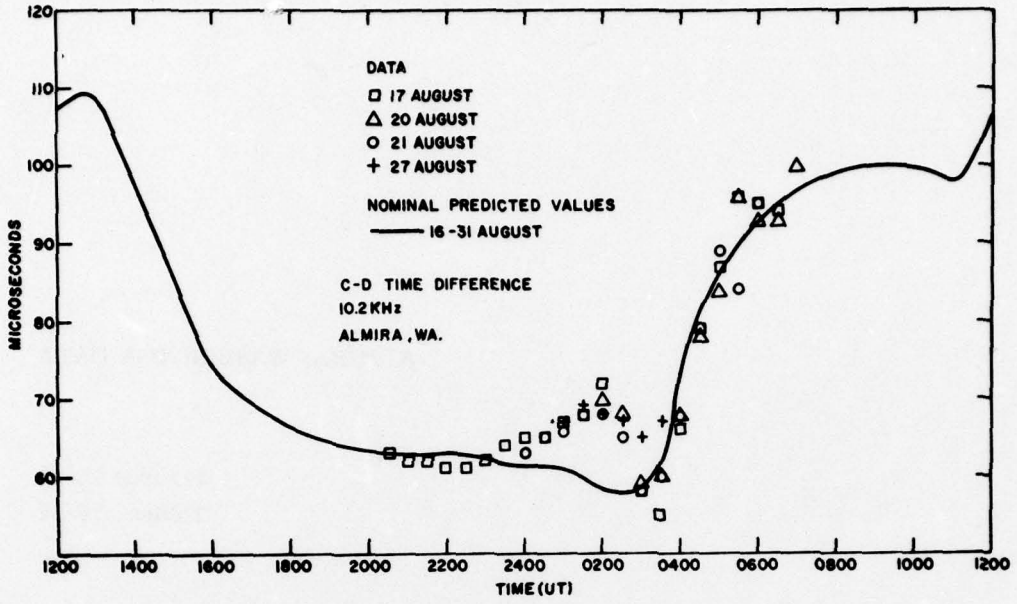

Figure 15. 10.2 kHz (C-D) Time Differences, Almira, 16-31 Aug

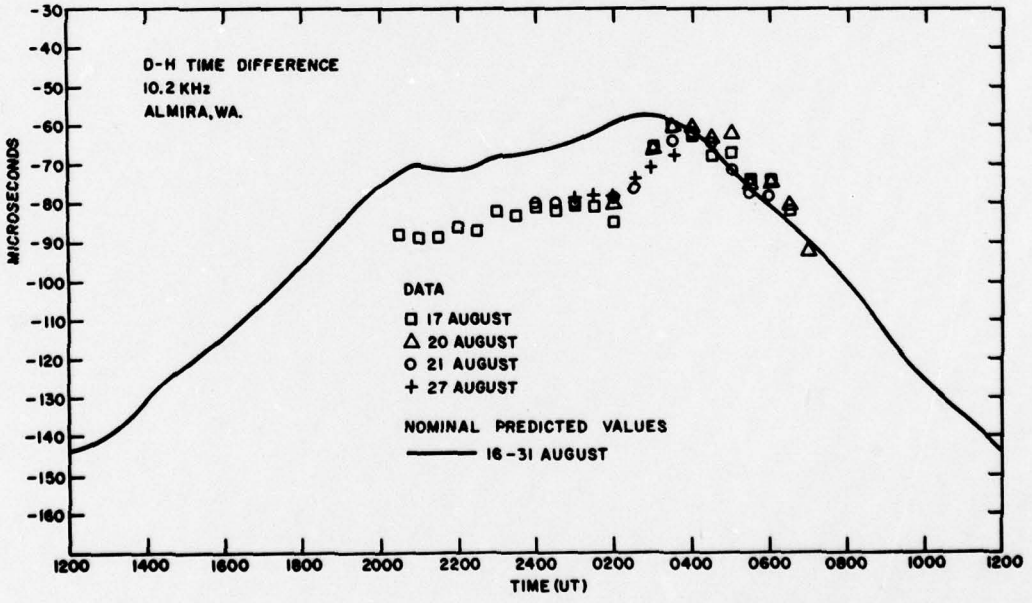

Figure 16. 10.2 kHz (D-H) Time Differences, Almira, 16-31 Aug

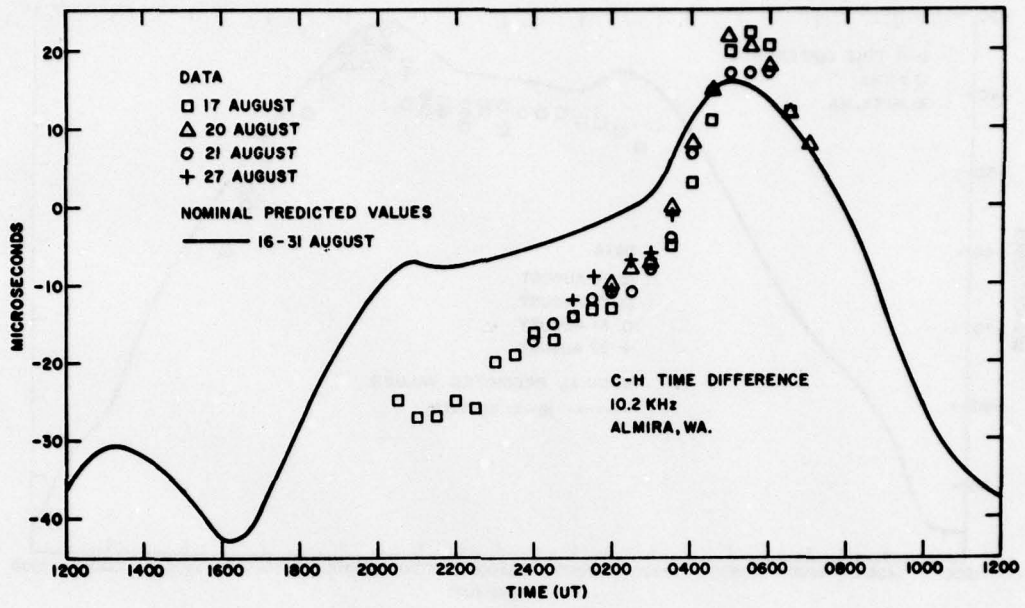

Figure 17. 10.2 kHz (C-H) Time Differences, Almira, 16-31 Aug

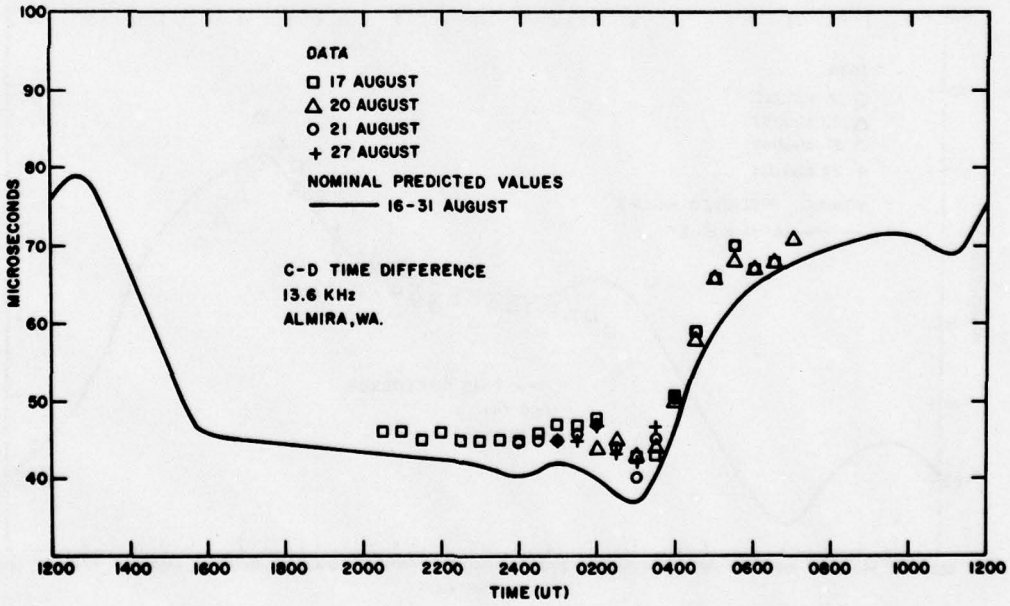

Figure 18. 13.6 kHz (C-D) Time Differences, Almira, 16-31 Aug

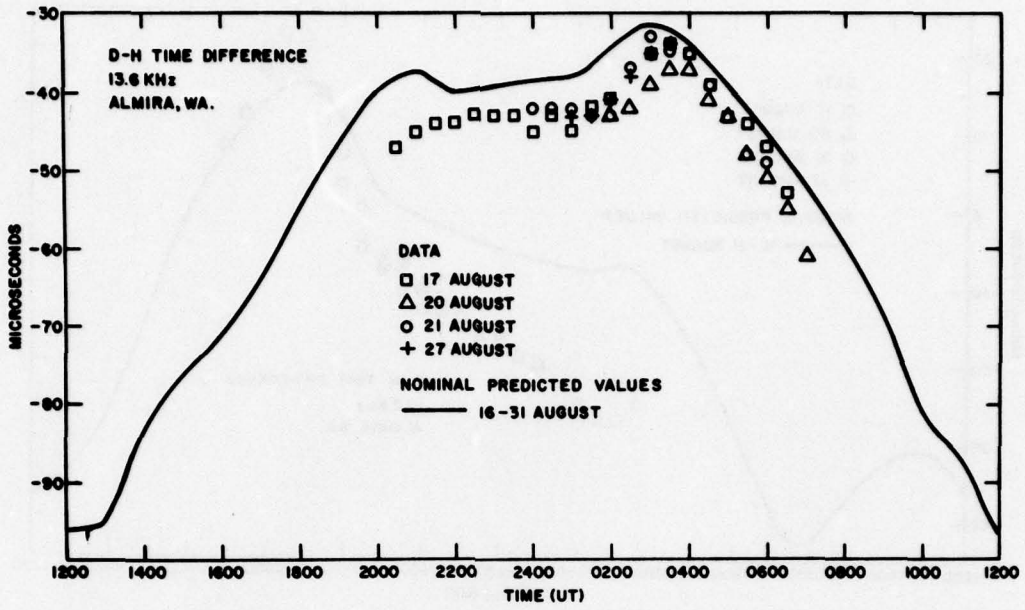

Figure 19. 13.6 kHz (D-H) Time Differences, Almira, 16-31 Aug

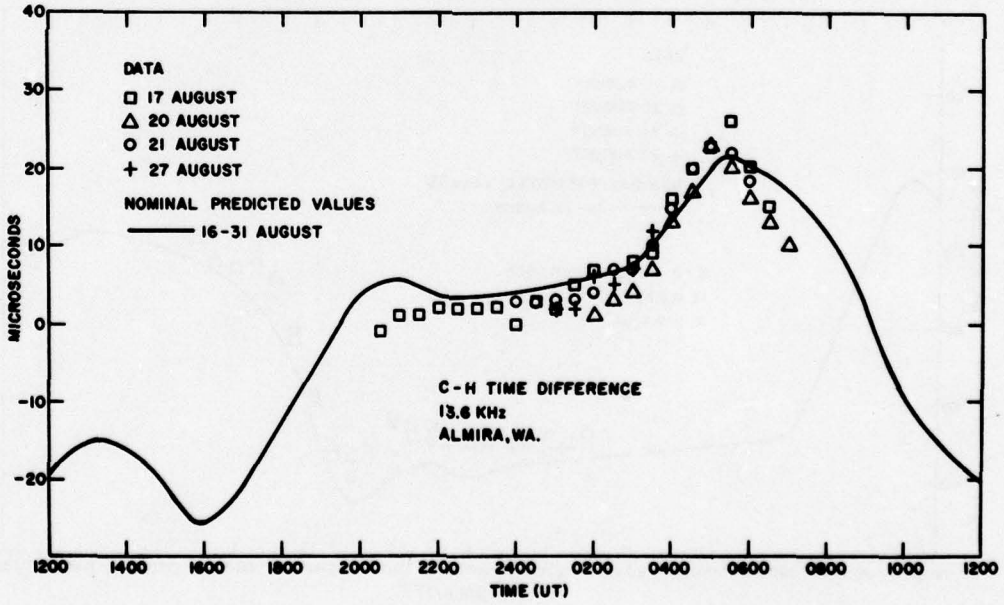

Figure 20. 13.6 kHz (C-H) Time Differences, Almira, 16-31 Aug

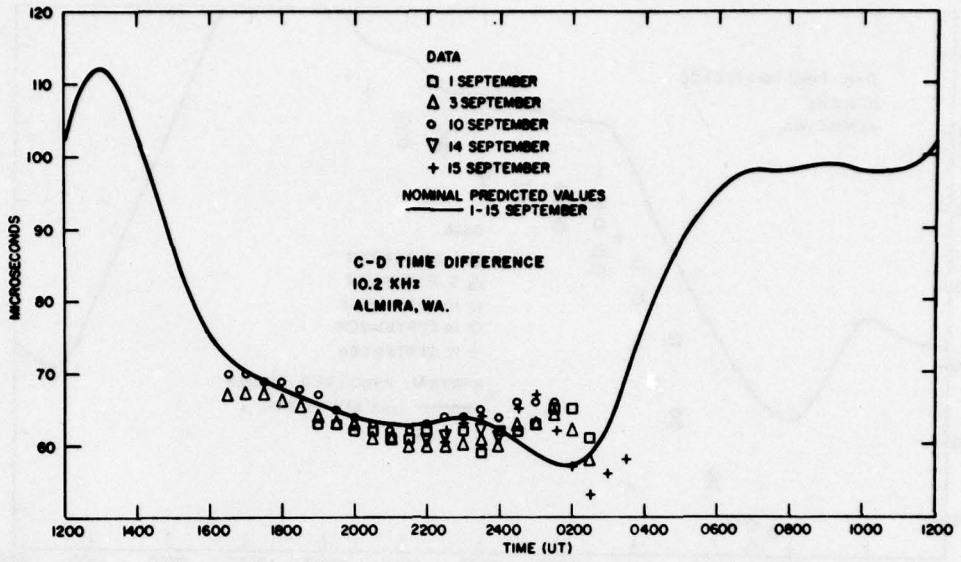

Figure 21. 10.2 kHz (C-D) Time Differences, Almira, 1-15 Sept

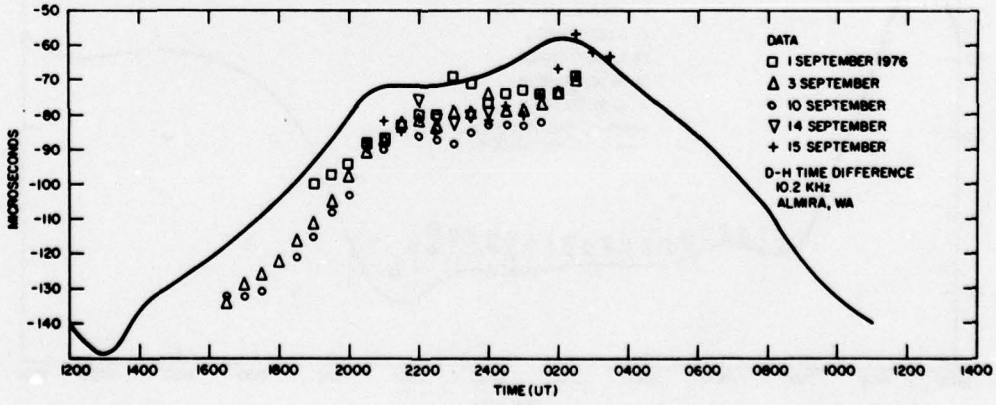

Figure 22. 10.2 kHz (D-H) Time Differences, Almira, 1-15 Sept

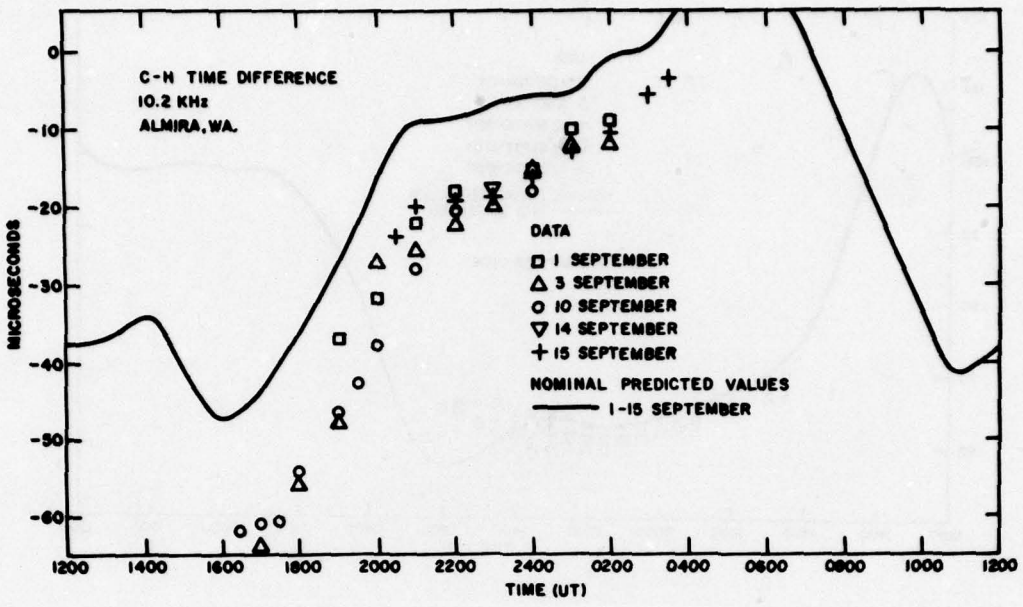

Figure 23. 10.2 kHz (C-H) Time Differences, Almira, 1-15 Sept

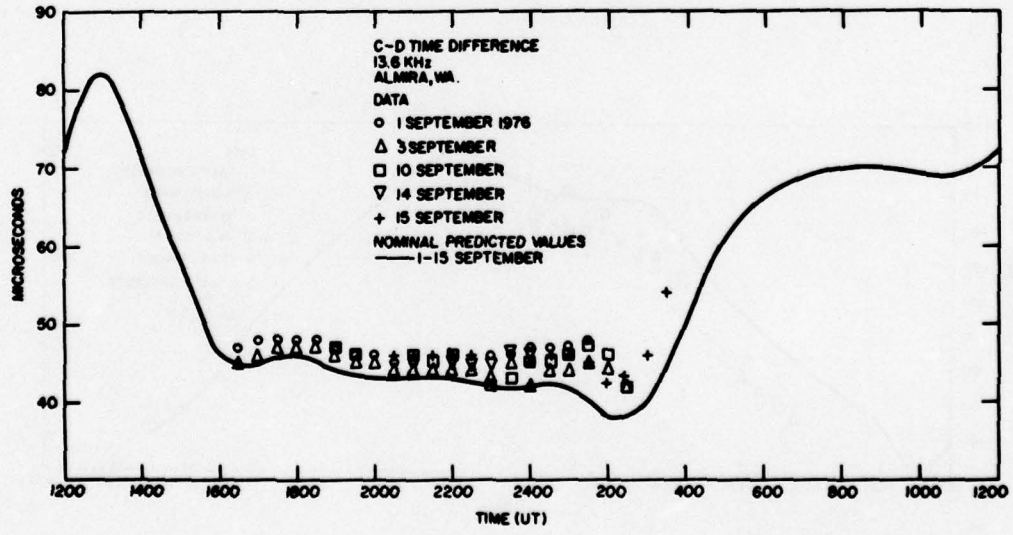

Figure 24. 13.6 kHz (C-D) Time Differences, Almira, 1-15 Sept

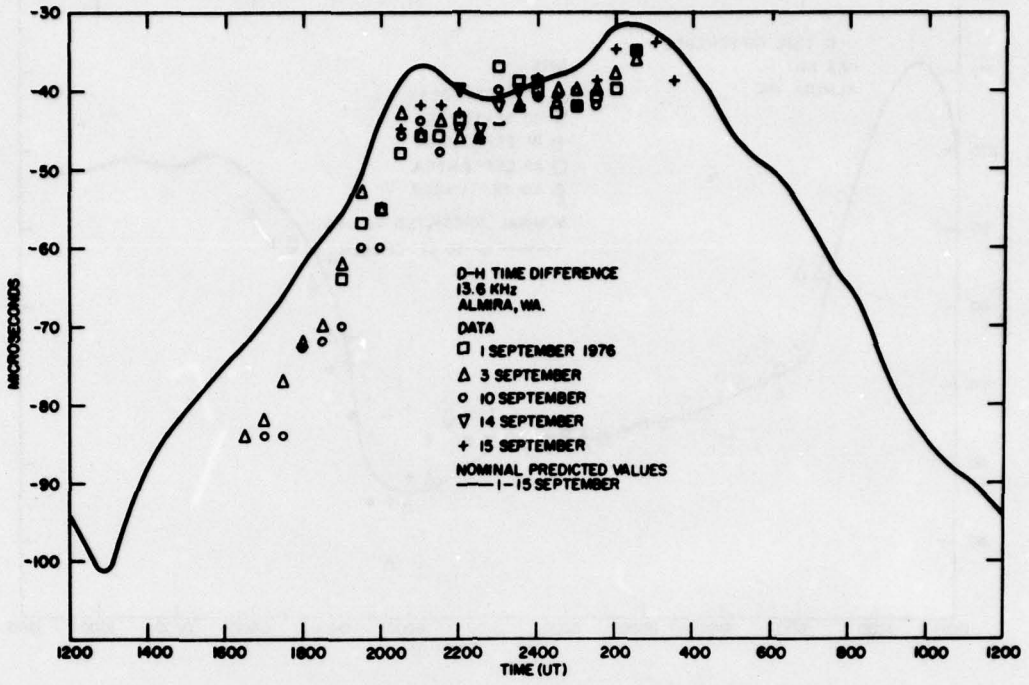

Figure 25. 13.6 kHz (D-H) Time Differences, Almira, 1-15 Sept

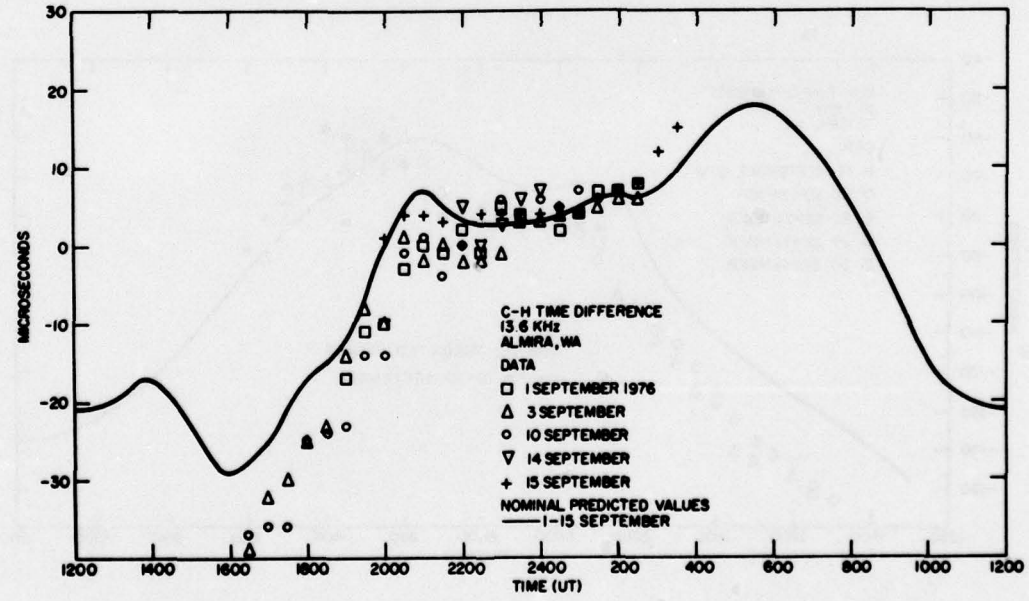

Figure 26. 13.6 kHz (C-H) Time Differences, Almira, 1-15 Sept

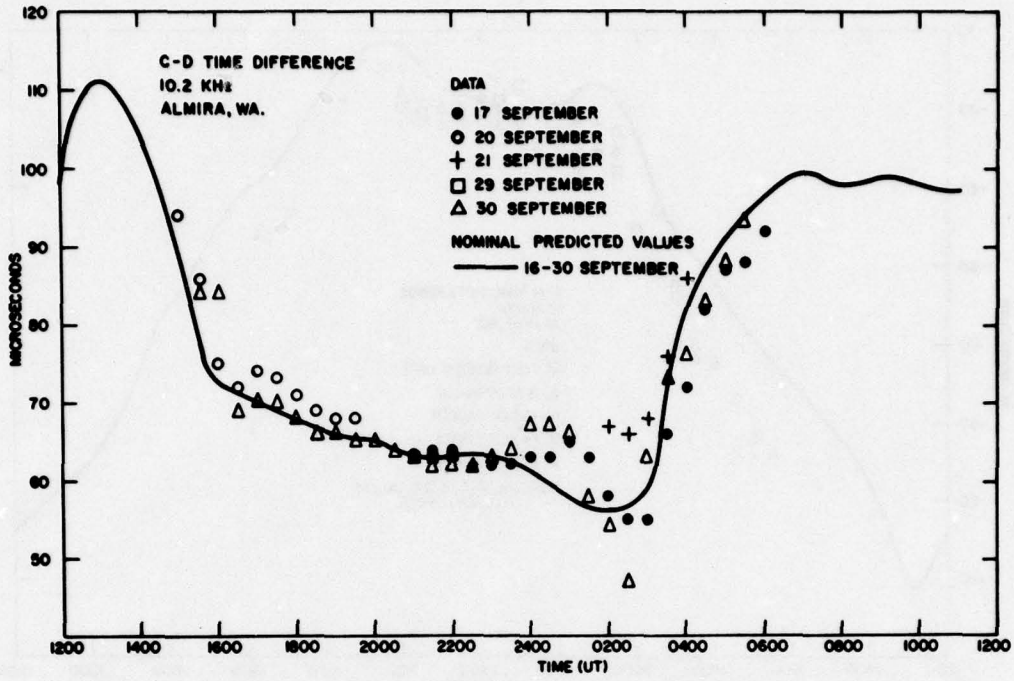

Figure 27. 10.2 kHz (C-D) Time Differences, Almira, 16-30 Sept

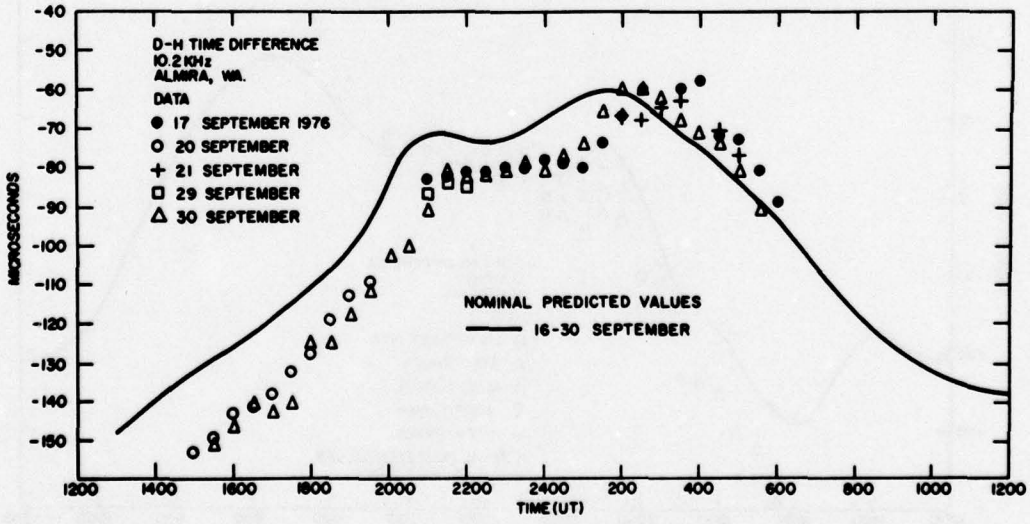

Figure 28. 10.2 kHz (D-H) Time Differences, Almira, 16-30 Sept

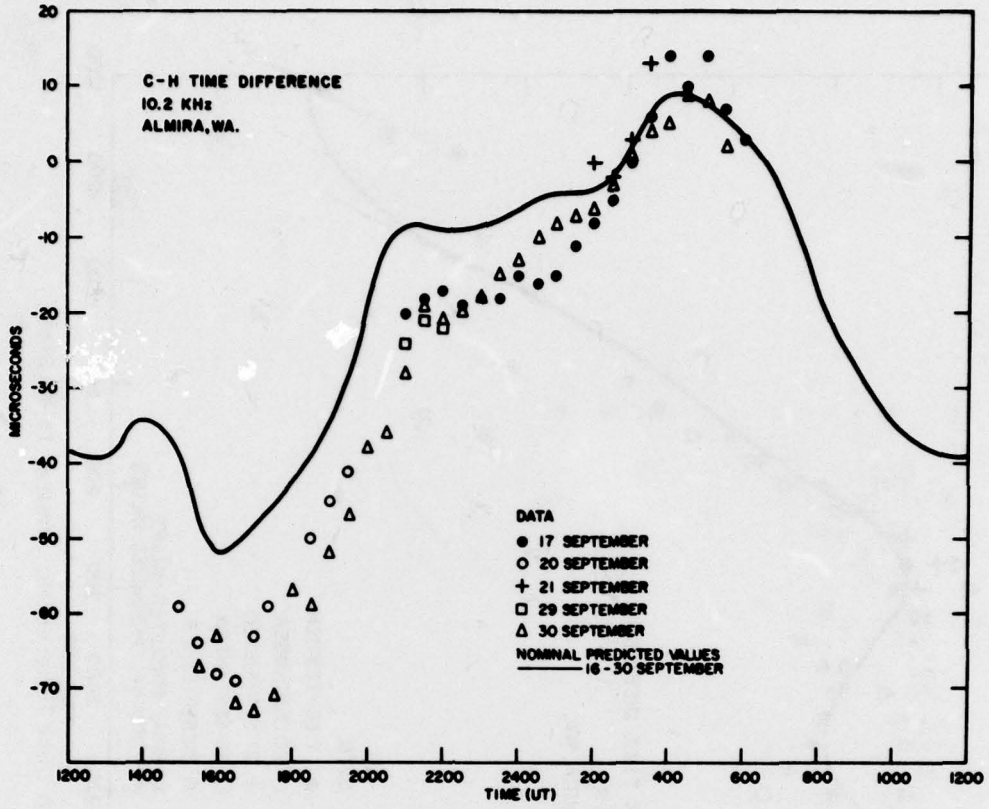

Figure 29. 10.2 kHz (C-H) Time Differences, Almira, 16-30 Sept

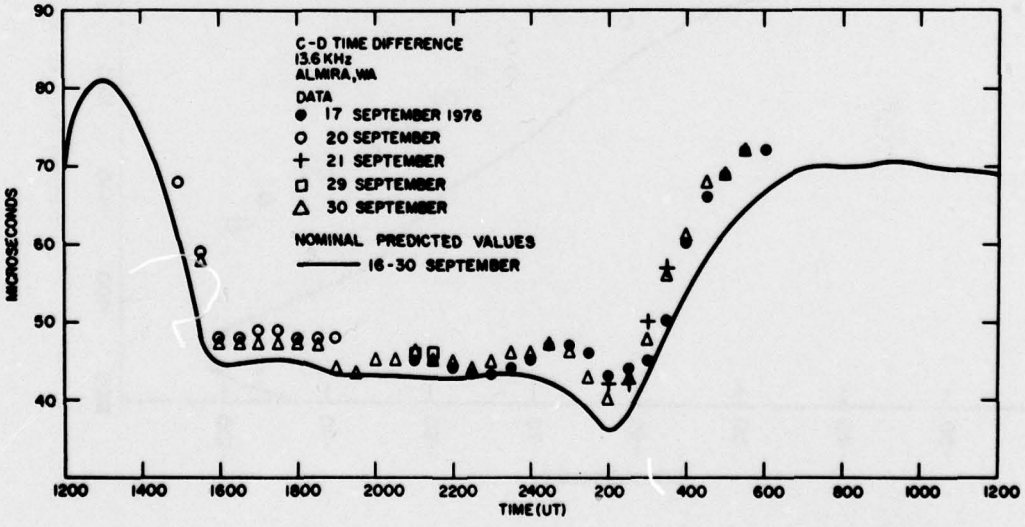

Figure 30. 13.6 kHz (C-D) Time Differences, Almira, 16-30 Sept

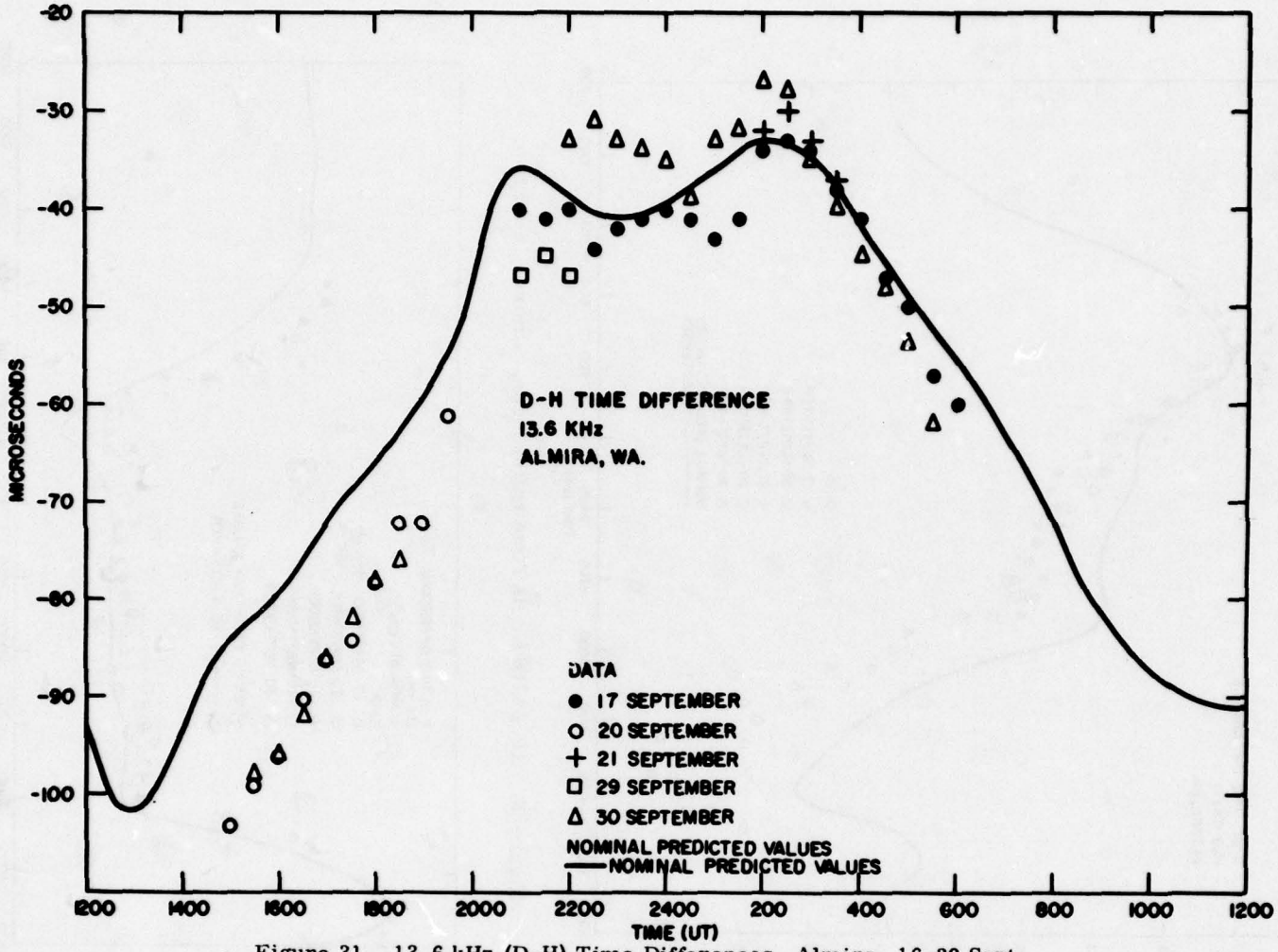

Figure 31. 13.6 kHz (D-H) Time Differences, Almira, 16-30 Sept

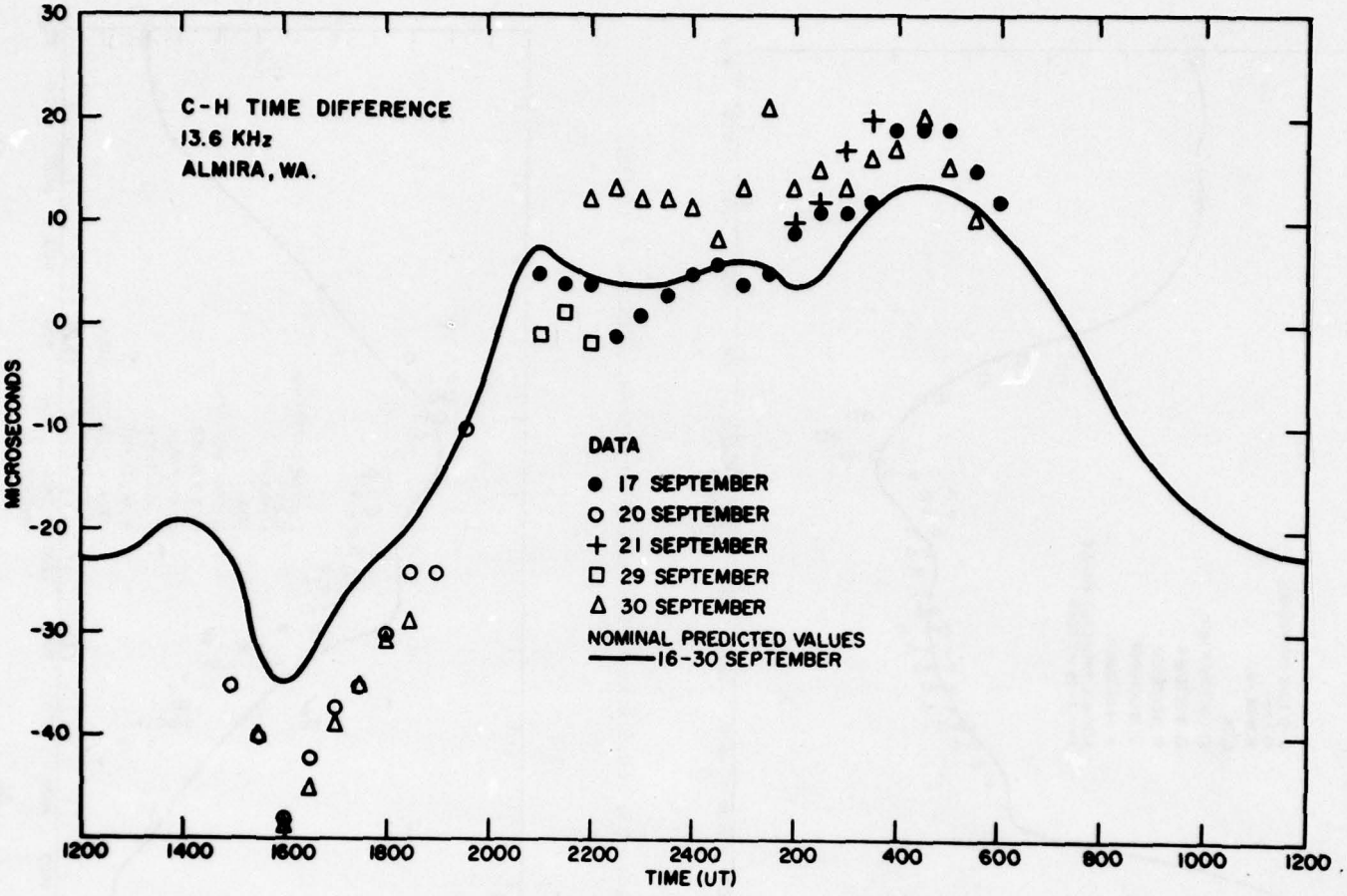

Figure 32. 13.6 kHz (C-H) Time Differences, Almira, 16-30 Sept

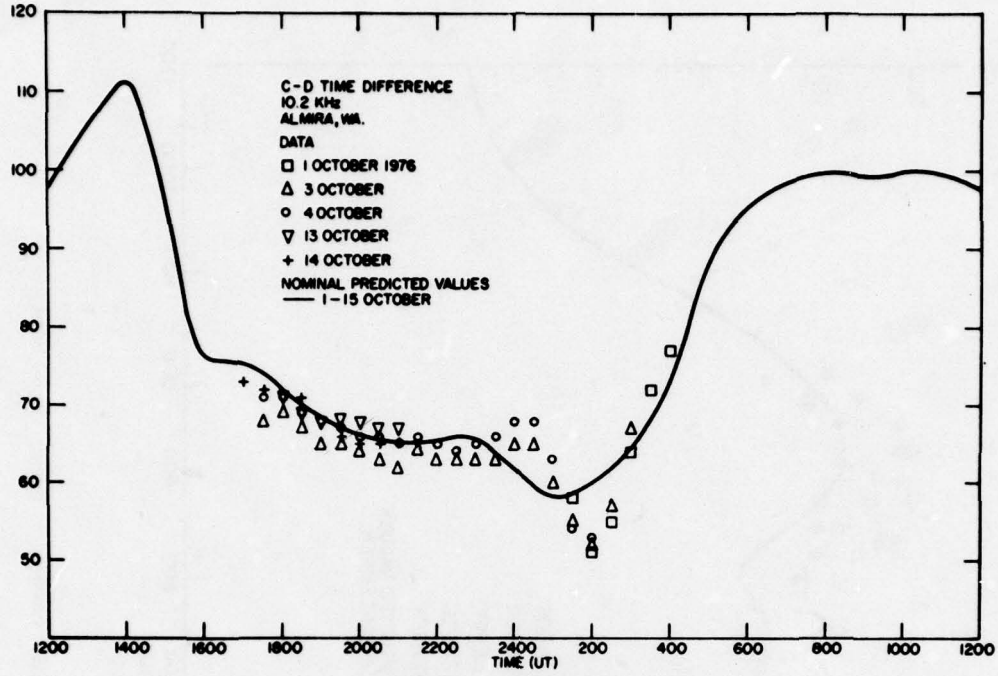

Figure 33. 10.2 kHz (C-D) Time Differences, Almira, 1-15 Oct

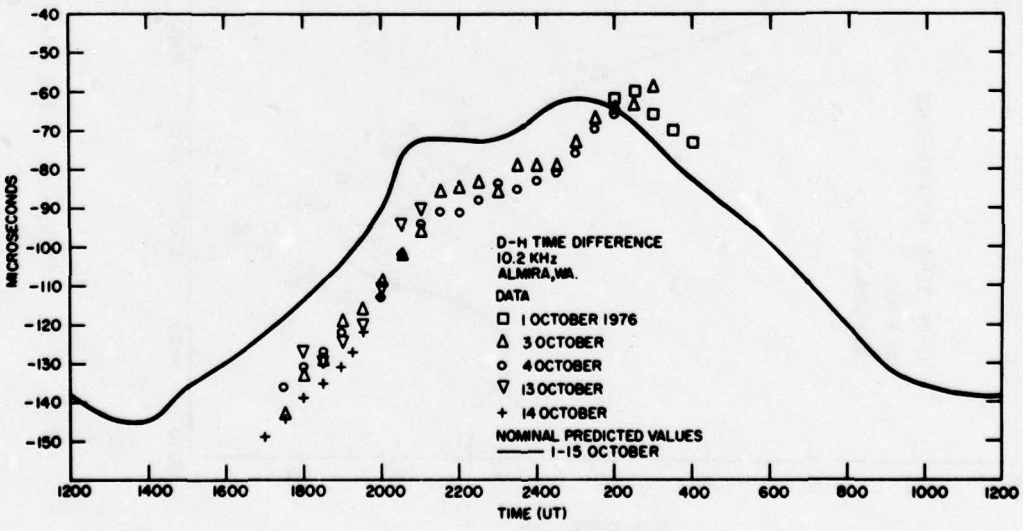

Figure 34. 10.2 kHz (D-H) Time Differences, Almira, 1-15 Oct

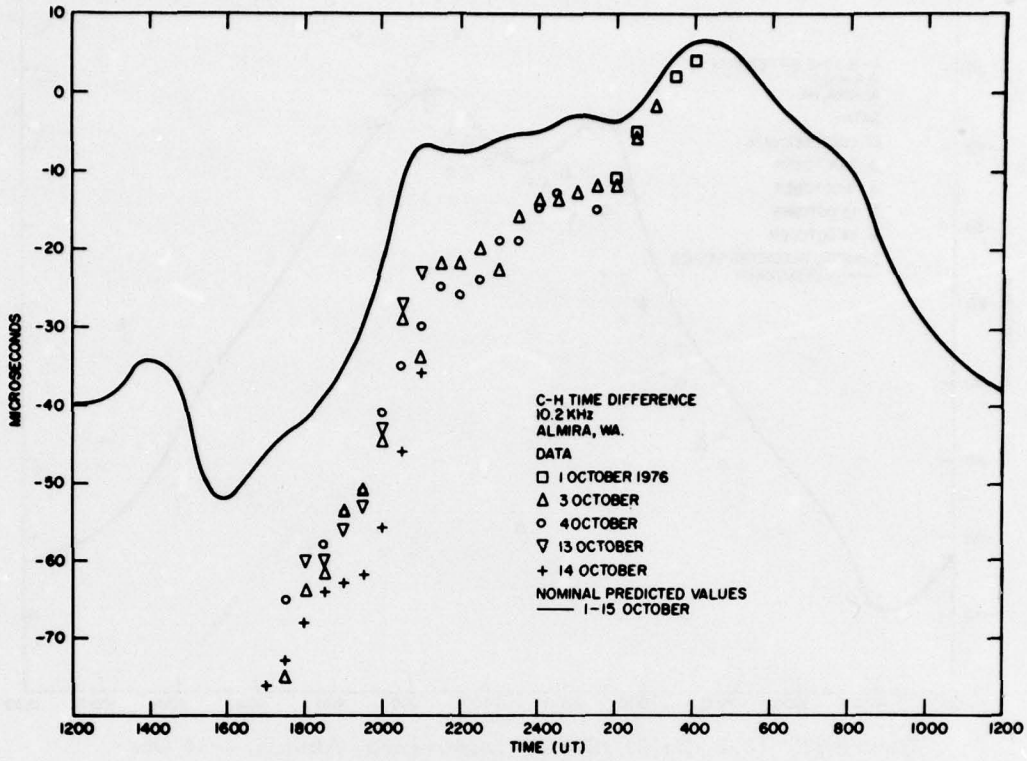

Figure 35. 10.2 kHz (C-H) Time Differences, Almira, 1-15 Oct

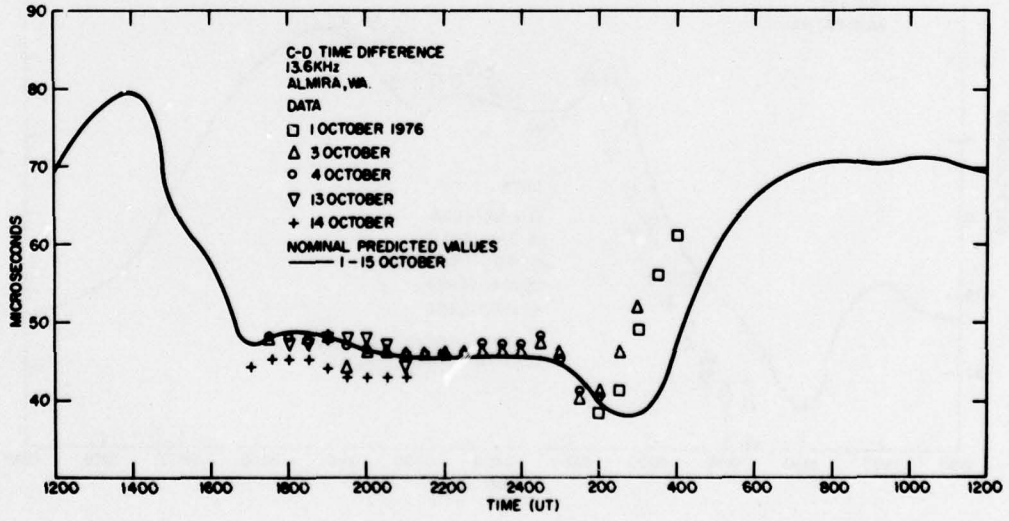

Figure 36. 13.6 kHz (C-D) Time Differences, Almira, 1-15 Oct

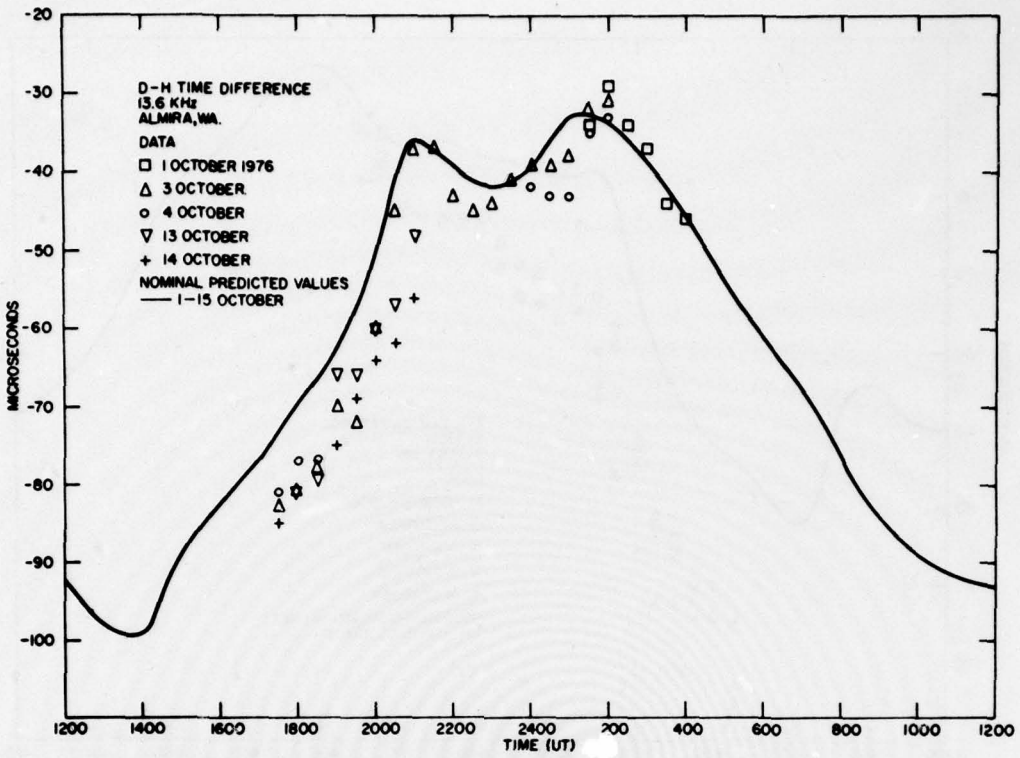

Figure 37. 13.6 kHz (D-H) Time Differences, Almira, 1-15 Oct

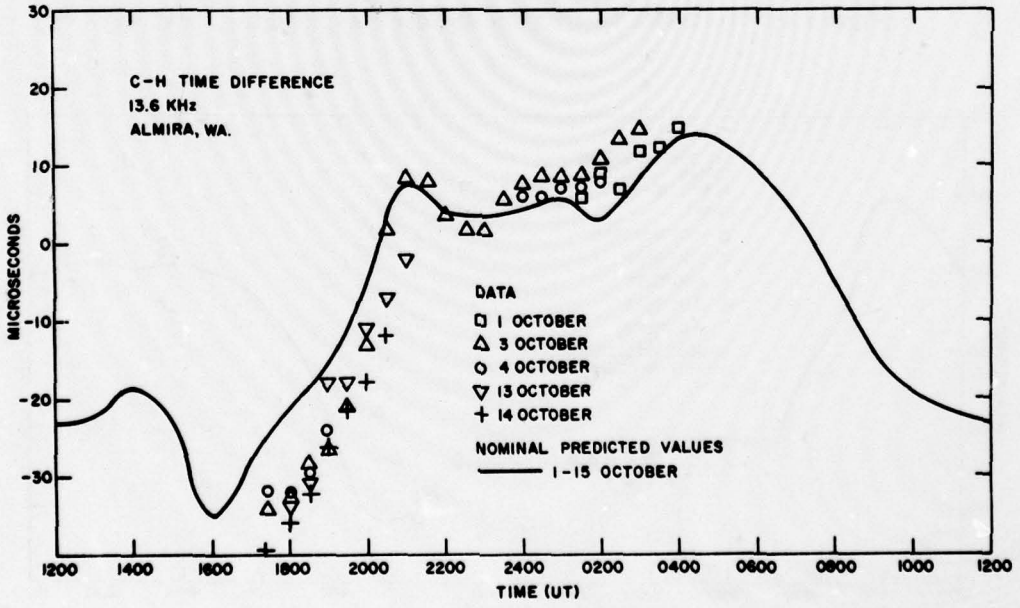

Figure 38. 13.6 kHz (C-H) Time Differences, Almira, 1-15 Oct

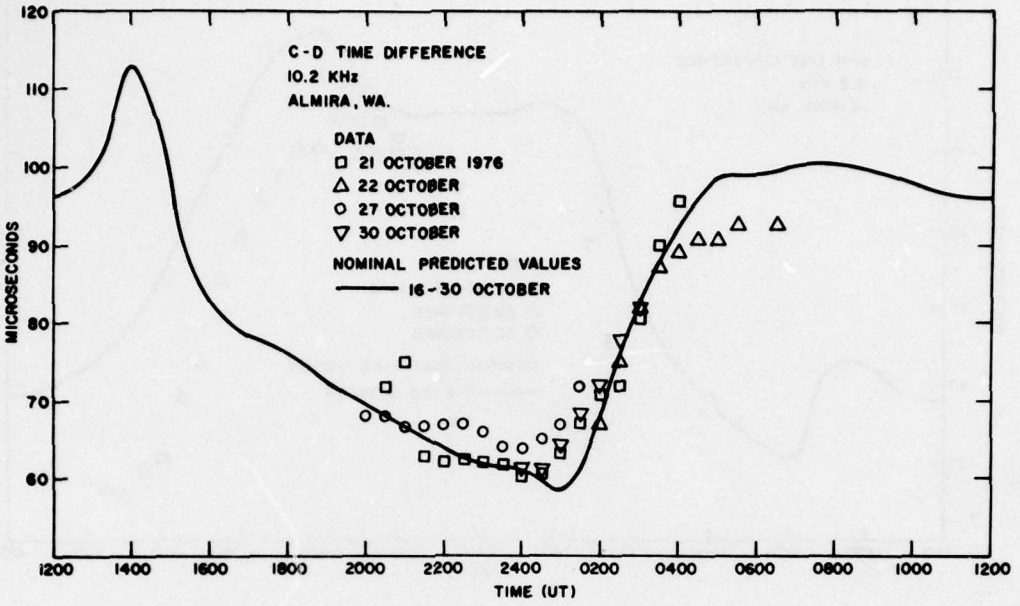

Figure 39. 10.2 kHz (C-D) Time Differences, Almira, 16-31 Oct

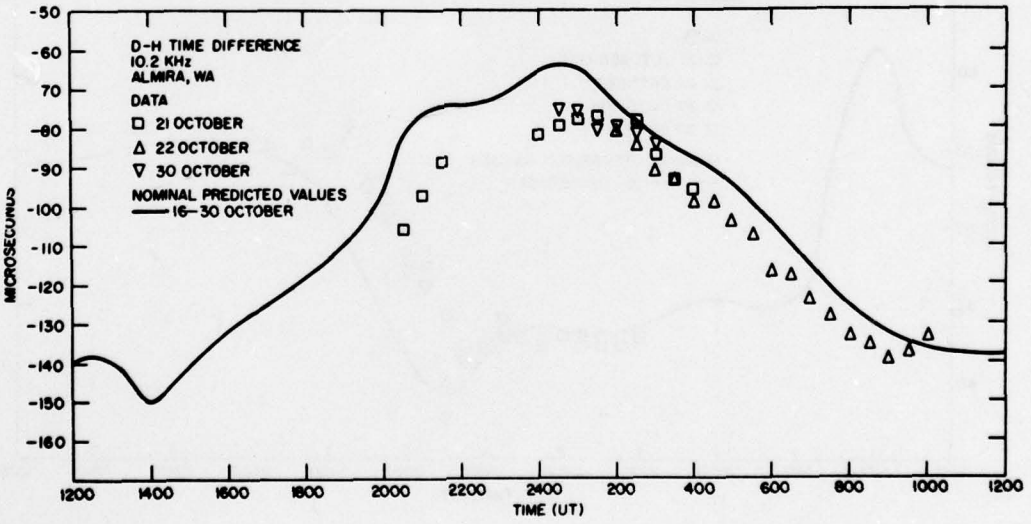

Figure 40. 10.2 kHz (D-H) Time Differences, Almira, 16-31 Oct

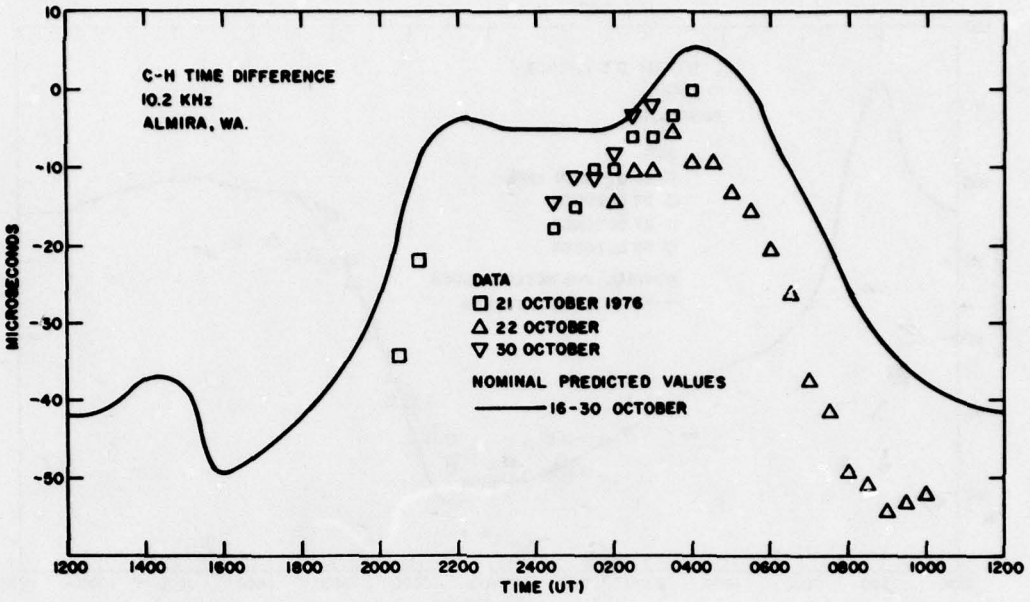

Figure 41. 10.2 kHz (C-H) Time Differences, Almira, 16-31 Oct

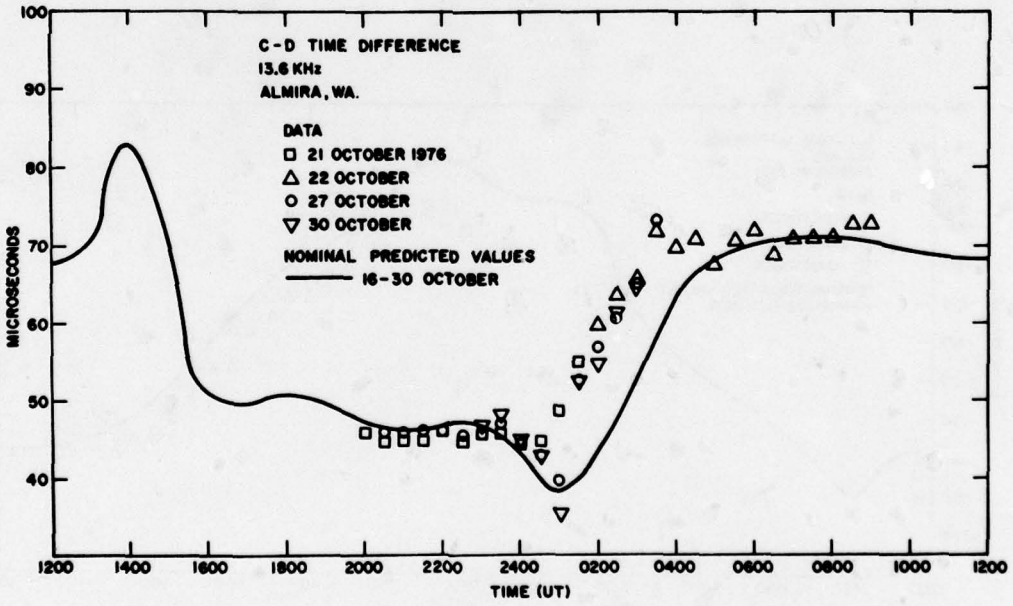

Figure 42. 13.6 kHz (C-D) Time Differences, Almira, 16-31 Oct

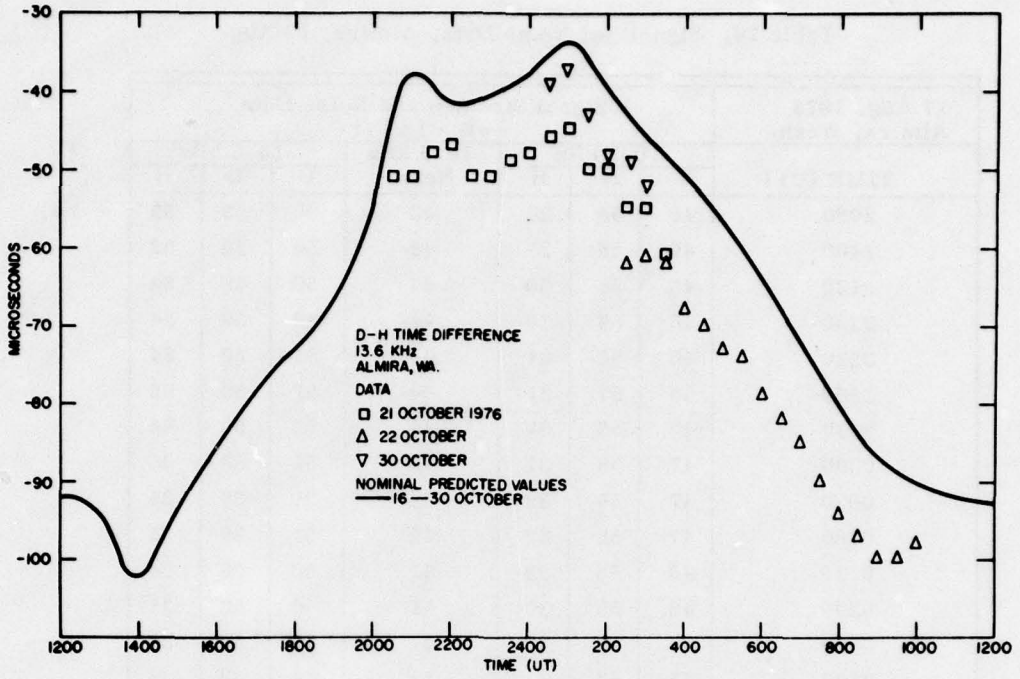

Figure 43. 13.6 kHz (D-H) Time Differences, Almira, 16-31 Oct

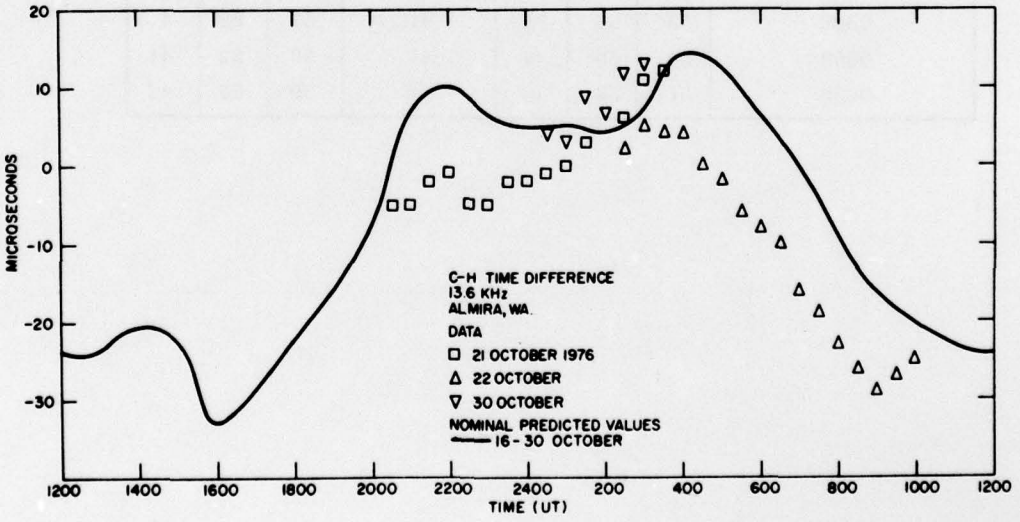

Figure 44. 13.6 kHz (C-H) Time Differences, Almira, 16-31 Oct

Table 10. Signal and Noise Data, Almira, 17 Aug.

17 Aug. 1976 Almira, Wash.	Signal Strength and Noise Data dB > 1 μV/m						
	10.2 kHz			10.6 kHz	13.6 kHz		
TIME (UT)	C	D	H	Noise	C	D	H
2030	46	56	28	43	50	59	32
2100	46	56	27	43	50	59	32
2130	46	56	30	44	50	59	34
2200	46	56	30	44	50	59	34
2230	46	56	31	44	51	59	34
2300	46	57	31	44	51	59	35
2330	47	56	31	44	51	59	35
0000	47	56	31	43	51	59	35
0030	47	56	32	44	51	59	35
0100	47	56	32	42	51	59	35
0130	46	55	32	41	50	58	34
0200	46	55	30	41	50	58	35
0230	46	56	30	41	49	58	35
0300	45	57	31	41	48	58	35
0330	45	57	31	41	48	60	36
0400	45	57	33	40	47	61	38
0430	45	56	33	40	48	60	39
0500	49	56	33	40	50	61	41
0530	52	56	35	41	50	62	41
0600	50	59	36	41	50	62	41
0630	51	58	35	40	50	62	42

Table 11. Signal and Noise Data, Almira, 20 Aug.

20 Aug. 1976 Almira, Wash.	Signal Strength and Noise Data dB > 1 μV/m						
	10.2 kHz			10.6 kHz	13.6 kHz		
TIME (UT)	C	D	H	Noise	C	D	H
0200	46	54	29	42	50	57	35
0230	45	54	29	42	50	58	35
0300	45	56	31	43	48	57	35
0330	44	56	31	43	47	58	35
0400	44	56	29	43	45	59	38
0430	45	56	33	44	47	60	40
0500	48	58	36	43	50	62	42
0530	50	56	34	45	50	62	42
0600	50	55	36	43	50	61	43
0630	49	56	37	45	51	62	44
0700	50	58	37	46	53	61	44

Table 12. Signal and Noise Data, Almira, 21 Aug.

21 Aug. 1976 Almira, Wash.	Signal Strength and Noise Data dB > 1 μV/m						
	10.2 kHz			10.6 kHz	13.6 kHz		
TIME (UT)	C	D	H	Noise	C	D	H
0000	46	56	31	39	50	58	35
0030	46	56	32	39	50	58	35
0100	46	56	31	37	50	58	35
0130	46	56	31	38	50	58	35
0200	46	55	33	39	50	58	35
0230	45	54	30	39	50	57	35
0300	45	57	31	39	50	57	35
0330	44	57	33	40	48	60	35
0400	44	58	31	39	45	61	38
0430	46	58	32	40	48	62	40
0500	49	58	33	39	50	61	42
0530	51	57	35	39	50	60	42
0600	49	54	36	39	51	60	42

Table 13. Signal and Noise Data, Almira, 27 Aug.

27 Aug. 1976 Almira, Wash.	Signal Strength and Noise Data dB > 1 μV/m						
	10.2 kHz			10.6 kHz	13.6 kHz		
TIME (UT)	C	D	H	Noise	C	D	H
0100	47	55	26	38	49	57	25
0130	48	55	25	37	49	57	28
0200	47	55	26	38	48	57	27
0230	47	56	26	38	48	57	26
0300	46	57	26	38	48	57	26
0330	45	57	30	37	47	56	33

Table 14. Signal and Noise Data, Almira, 1 Sept.

1 Sept. 1976 Almira, Wash.	Signal Strength and Noise Data dB > 1 μV/m						
	10.2 kHz			10.6 kHz	13.6 kHz		
TIME (UT)	C	D	H	Noise	C	D	H
1900	47	56	30	40	50	57	30
1930	47	56	30	39	50	58	32
2000	47	56	29	39	50	57	30
2030	47	55	27	39	50	57	28
2100	47	55	28	39	50	57	30
2130	47	55	28	38	50	57	30
2200	47	55	30	38	51	57	31
2230	47	55	30	39	50	57	31
2300	47	55	32	39	51	57	35
2330	46	55	31	38	50	58	33
0000	47	55	31	38	50	57	33
0030	47	55	30	38	49	57	33
0100	47	55	30	39	49	57	33
0130	47	55	30	38	49	57	33
0200	48	55	31	39	50	57	35
0230	47	56	30	40	49	56	35

Table 15. Signal and Noise Data, Almira, 3 Sept.

3 Sept. 1976 Almira, Wash.	Signal Strength and Noise Data dB > 1 μV/m						
	10.2 kHz			10.6 kHz	13.6 kHz		
TIME (UT)	C	D	H	Noise	C	D	H
1630	45	55	33	33	46	57	36
1700	45	56	33	32	47	57	33
1730	46	56	35	32	48	57	32
1800	47	56	30	32	48	57	32
1830	47	55	30	33	49	57	30
1900	47	55	27	34	50	57	25
1930	47	55	27	36	50	57	27
2000	47	55	26	36	50	57	27
2030	47	55	23	37	50	57	22
2100	47	55	27	37	50	57	29
2130	47	56	28	37	50	57	29
2200	47	56	30	37	50	57	31
2230	47	55	30	38	50	57	33
2300	48	55	31	37	50	57	32
2330	47	55	30	36	50	57	32
0000	47	55	31	36	50	57	33
0030	47	55	32	36	49	57	33
0100	46	55	30	36	49	57	33
0130	46	55	30	34	49	57	33
0200	46	55	30	35	48	57	34
0230	46	56	31	36	48	56	35

Table 16. Signal and Noise Data, Almira, 10 Sept.

10 Sept. 1976 Almira, Wash.	Signal Strength and Noise Data dB > 1 uV/m						
	10.2 kHz			10.6 kHz	13.6 kHz		
TIME (UT)	C	D	H	Noise	C	D	H
1630	45	55	25	37	45	57	30
1700	45	55	25	37	46	57	29
1730	46	55	25	37	47	57	20
1800	47	55	23	37	48	57	17
1830	47	55	22	35	49	57	18
1900	47	55	20	34	49	58	17
1930	47	55	16	33	49	57	17
2000	47	55	10	33	49	57	17
2030	47	55	7	32	49	57	17
2100	47	55	7	32	49	57	17
2130	47	54	13	32	49	57	17
2200	47	54	17	31	49	57	17
2230	47	54	16	31	50	57	17
2300	47	54	17	33	50	57	17
2330	48	54	18	32	50	57	17
0000	47	54	16	31	50	57	17
0030	47	54	17	31	50	57	17
0100	46	53	15	31	49	57	17
0130	46	53	14	32	49	56	17

Table 17. Signal and Noise Data, Almira, 14 Sept.

14 Sept. 1976 Almira, Wash.	Signal Strength and Noise Data db > 1 uV/m						
	10.2 kHz			10.6 kHz	13.6 kHz		
TIME (UT)	C	D	H	Noise	C	D	H
2200	48	54	27	41	50	58	30
2230	48	54	29	41	50	57	31
2300	48	54	28	41	49	57	32
2330	48	54	26	41	50	57	32
0000	48	54	28	41	50	57	30

Table 18. Signal and Noise Data, Almira, 15 Sept.

15 Sept. 1976 Almira, Wash.	Signal Strength and Noise Data dB > 1 μV/m						
	10.2 kHz			10.6 kHz	13.6 kHz		
TIME (UT)	C	D	H	Noise	C	D	H
2030	47	55	25	38	49	57	26
2100	47	55	28	39	49	57	30
2130	47	55	27	39	50	57	30
2200	47	54	29	40	50	57	30
2230	47	54	27	42	50	57	32
2300	47	54	30	41	50	57	33
2330	47	54	31	40	50	57	33
0000	47	54	30	40	50	57	32
0030	47	54	31	42	49	57	33
0100	47	54	30	42	49	57	33
0130	47	54	29	40	49	56	33
0200	46	54	31	40	49	56	35
0230	45	56	29	41	48	57	34
0300	44	56	30	41	47	59	36
0330	46	56	32	40	47	60	39

Table 19. Signal and Noise Data, Almira, 17 Sept.

17 Sept. 1976 Almira, Wash.	Signal Strength and Noise Data db > 1 μV/m						
	10.2 kHz			10.6 kHz	13.6 kHz		
TIME (UT)	C	D	H	Noise	C	D	H
2100	48	55	30	40	49	58	29
2130	48	55	30	40	49	57	30
2200	48	55	29	42	49	58	30
2230	48	55	30	42	49	58	32
2300	48	55	31	42	49	57	31
2330	47	55	31	42	49	57	34
0000	47	55	31	42	49	57	35
0030	47	54	32	42	49	57	35
0100	47	54	30	42	49	57	32
0130	47	54	31	42	49	56	33
0200	47	55	33	41	49	56	33
0230	46	56	31	42	48	56	35
0300	45	55	30	42	47	58	37
0330	45	55	30	42	47	60	40
0400	47	56	32	43	48	60	40
0430	50	55	34	42	49	60	40
0500	50	55	36	42	49	60	41
0530	49	55	38	39	50	60	41
0600	49	52	37	40	51	59	41

Table 20. Signal and Noise Data, Almira, 20 Sept.

20 Sept. 1976 Almira, Wash.	Signal Strength and Noise Data dB > 1 μV/m						
	10.2 kHz			10.6 kHz	13.6 kHz		
TIME (UT)	C	D	H	Noise	C	D	H
1400	51	55	39	31	50	57	39
1430	50	55	39	32	52	57	39
1500	47	54	37	33	47	57	36
1530	45	54	36	32	48	57	37
1600	42	55	35	32	45	57	37
1630	44	55	34	31	47	57	33
1700	46	55	32	32	48	57	34
1730	45	55	31	32	48	57	33
1800	47	55	31	33	49	57	30
1830	46	55	30	33	49	57	32
1900	47	55	29	33	49	58	30
1930	48	55	29	33	49	58	18

Table 21. Signal and Noise Data, Almira, 21 Sept.

21 Sept. 1976 Almira, Wash.	Signal Strength and Noise Data dB > 1 μV/m						
	10.2 kHz			10.6 kHz	13.6 kHz		
TIME (UT)	C	D	H	Noise	C	D	H
0200	47	55	30	40	48	58	31
0230	47	55	33	40	48	57	31
0300	46	57	33	40	47	55	38
0330	47	58	33	41	46	56	40
0400	49	58	33	41	47	54	38
0430	52	58	32	41	49	56	41
0500	52	58	32	40	49	55	40

Table 22. Signal and Noise Data, Almira, 29 Sept.

29 Sept. 1976 Almira, Wash.	Signal Strength and Noise Data dB > 1 μV/m						
	10.2 kHz			10.6 kHz	13.6 kHz		
TIME (UT)	C	D	H	Noise	C	D	H
2100	46	55	--	32	45	54	--
2130	46	56	23	32	45	53	--
2200	46	56	24	33	44	53	--

Table 23. Signal and Noise Data, Almira, 30 Sept.

30 Sept. 1976 Almira, Wash.	Signal Strength and Noise Data dB > 1 μV/m						
	10.2 kHz			10.6 kHz	13.6 kHz		
TIME (UT)	C	D	H	Noise	C	D	H
1530	44	54	9	31	43	52	33
1600	41	54	9	31	39	53	33
1630	43	55	9	31	42	53	33
1700	44	55	9	31	42	53	31
1730	45	55	9	32	42	53	31
1800	46	56	9	33	43	53	29
1830	46	56	9	33	43	53	21
1900	47	55	9	32	43	53	24
1930	47	55	9	32	44	53	--
2000	47	55	9	33	44	53	--
2030	47	55	9	32	44	53	--
2100	47	55	9	32	44	53	--
2130	47	55	9	32	44	53	--
2200	46	55	9	31	44	53	--
2230	46	54	9	32	44	52	24
2300	46	54	9	33	44	52	24
2330	46	54	10	33	44	52	27
0000	46	54	10	32	44	52	27
0030	46	53	10	31	44	52	26
0100	45	53	9	32	44	52	26
0130	44	55	9	33	43	51	28
0200	44	56	9	35	42	53	27
0230	44	56	9	35	40	54	29
0300	45	57	11	36	42	54	31
0330	47	56	10	36	43	55	31
0400	49	55	10	37	46	56	33
0430	51	54	10	36	46	56	34
0500	50	55	9	35	44	54	34
0530	49	56	9	36	45	55	35

Table 24. Signal and Noise Data, Almira, 1 Oct.

1 Oct. 1976 Almira, Wash.	Signal Strength and Noise Data db > 1 μV/m						
	10.2 kHz			10.6 kHz	13.6 kHz		
TIME (UT)	C	D	H	Noise	C	D	H
0130	46	56	27	38	43	52	25
0200	44	56	12	39	42	54	25
0230	43	55	17	36	40	54	27
0300	45	55	14	36	42	54	31
0330	47	56	12	36	43	54	33
0400	48	55	9	37	44	55	33

Table 25. Signal and Noise Data, Almira, 3 Oct.

3 Oct. 1976 Almira, Wash.	Signal Strength and Noise Data dB > 1 μV/m						
	10.2 kHz			10.6 kHz	13.6 kHz		
TIME (UT)	C	D	H	Noise	C	D	H
1730	46	55	10	32	41	53	27
1800	46	55	9	31	42	53	27
1830	46	55	9	30	43	53	17
1900	47	55	9	31	43	53	16
1930	47	55	9	32	44	53	16
2000	47	55	9	31	44	53	16
2030	47	55	9	32	44	53	16
2100	47	55	9	31	44	53	16
2130	47	55	9	31	44	53	16
2200	43	55	9	31	41	53	16
2230	47	55	9	31	44	53	16
2300	47	55	9	31	44	53	16
2330	47	54	9	31	44	53	17
0000	47	54	9	31	44	52	28
0030	46	53	9	32	43	52	28
0100	46	53	9	32	43	52	27
0130	45	55	9	33	43	51	26
0200	43	57	9	35	41	54	28
0230	44	57	11	35	40	54	31
0300	45	55	11	36	41	55	33

Table 26. Signal and Noise Data, Almira, 4 Oct.

4 Oct. 1976 Almira, Wash.	Signal Strength and Noise Data db > 1 μV/m						
	10.2 kHz			10.6 kHz	13.6 kHz		
TIME (UT)	C	D	H	Noise	C	D	H
1730	44	55	9	30	41	53	26
1800	46	55	9	30	42	53	26
1830	47	55	9	33	43	53	27
1900	47	55	9	33	44	53	19
1930	47	55	9	33	44	53	17
2000	47	55	9	33	44	53	16
2030	47	55	9	33	44	53	16
2100	47	55	10	34	44	53	16
2130	46	55	9	33	44	53	16
2200	47	55	10	33	44	53	16
2230	47	55	11	35	44	53	16
2300	47	55	9	35	44	53	17
2330	46	54	9	34	44	53	21
0000	46	54	9	34	44	52	27
0030	46	54	9	34	44	52	25
0100	46	53	9	36	44	51	26
0130	45	56	10	37	43	52	26
0200	44	57	9	39	41	54	26

Table 27. Signal and Noise Data, Almira, 13 Oct.

13 Oct. 1976 Almira, Wash.	Signal Strength and Noise Data db > 1 μV/m						
	10.2 kHz			10.6 kHz	13.6 kHz		
TIME (UT)	C	D	H	Noise	C	D	H
1800	43	57	30	30	47	56	35
1830	43	57	29	30	47	56	33
1900	43	57	24	30	47	57	33
1930	43	58	24	30	47	57	33
2000	43	58	20	30	47	56	33
2030	43	56	15	30	47	56	34
2100	43	56	14	30	47	56	33

Table 28. Signal and Noise Data, Almira, 14 Oct.

14 Oct. 1976 Almira, Wash.	Signal Strength and Noise Data db > 1 μV/m						
	10.2 kHz			10.6 kHz	13.6 kHz		
TIME (UT)	C	D	H	Noise	C	D	H
1700	41	56	32	32	42	57	34
1730	43	56	30	30	44	57	33
1800	43	57	29	30	45	57	33
1830	44	57	29	30	46	57	33
1900	43	57	24	30	47	57	33
1930	43	57	--	30	47	57	33
2000	43	57	--	30	47	57	33
2030	43	56	--	30	47	57	33
2100	44	56	--	30	47	57	33

Table 29. Signal and Noise Data, Almira, 21 Oct.

21 Oct. 1976 Almira, Wash.	Signal Strength and Noise Data db > 1 μV/m						
	10.2 kHz			10.6 kHz	13.6 kHz		
TIME (UT)	C	D	H	Noise	C	D	H
2030	28	57	25	36	52	58	27
2100	28	56	22	36	52	58	27
2130	28	56	23	36	52	57	27
2200	47	56	23	36	52	57	27
2230	46	55	25	36	52	56	27
2300	46	55	26	36	51	56	32
2330	46	55	28	36	51	56	35
0000	46	55	28	36	51	55	35
0030	46	58	27	36	50	56	35
0100	45	60	26	36	50	56	36
0130	45	61	27	36	49	58	36
0200	46	60	29	36	50	59	37
0230	47	59	30	36	50	59	38
0300	47	59	31	36	51	58	39
0330	49	60	32	36	52	56	40
0400	51	60	33	36	--	--	--

Table 30. Signal and Noise Data, Almira, 22 Oct.

22 Oct. 1976 Almira, Wash.	Signal Strength and Noise Data db > 1 μV/m						
	10.2 kHz			10.6 kHz	13.6 kHz		
TIME (UT)	C	D	H	Noise	C	D	H
0200	45	61	27	36	43	62	27
0230	46	61	27	36	45	60	27
0300	48	60	29	37	52	59	37
0330	50	59	30	37	52	59	39
0400	51	58	30	37	53	61	38
0430	52	58	26	36	52	62	36
0500	50	58	28	36	52	62	37
0530	51	57	30	36	51	60	38
0600	52	58	33	36	49	59	40
0630	52	56	34	36	47	60	40
0700	50	56	33	36	47	60	40
0730	50	55	33	36	51	61	41
0800	49	55	35	36	52	60	42
0830	49	57	34	36	52	61	43
0900	48	56	33	36	51	60	42
0930	48	59	33	37	41	61	42
1000	49	59	33	37	41	61	40

Table 31. Signal and Noise Data, Almira, 27 Oct.

27 Oct. 1976 Almira, Wash.	Signal Strength and Noise Data db > 1 μV/m						
	10.2 kHz			10.6 kHz	13.6 kHz		
TIME (UT)	C	D	H	Noise	C	D	H
2000	47	57	--	24	54	58	--
2030	47	57	--	26	53	58	--
2100	47	56	--	30	54	58	--
2130	46	56	--	30	54	57	--
2200	46	56	--	29	54	56	--
2230	46	56	--	29	53	56	--
2300	46	56	--	26	53	55	--
2330	46	55	--	26	53	54	--
0000	46	57	--	29	53	54	--
0030	46	59	--	26	52	55	--
0100	45	60	--	26	52	55	--
0130	46	60	--	26	52	57	--

Table 32. Signal and Noise Data, Almira, 30 Oct.

30 Oct. 1976 Almira, Wash.	Signal Strength and Noise Data dB > 1 μV/m						
	10.2 kHz			10.6 kHz	13.6 kHz		
TIME (UT)	C	D	H	Noise	C	D	H
2330	45	55	29	--	53	55	26
0000	45	55	27	--	53	54	27
0030	44	59	28	--	53	55	33
0100	44	59	28	--	52	54	33
0130	44	61	29	--	51	53	35
0200	45	61	29	--	52	57	36
0230	45	61	31	--	52	57	38
0300	46	59	32	--	53	58	39